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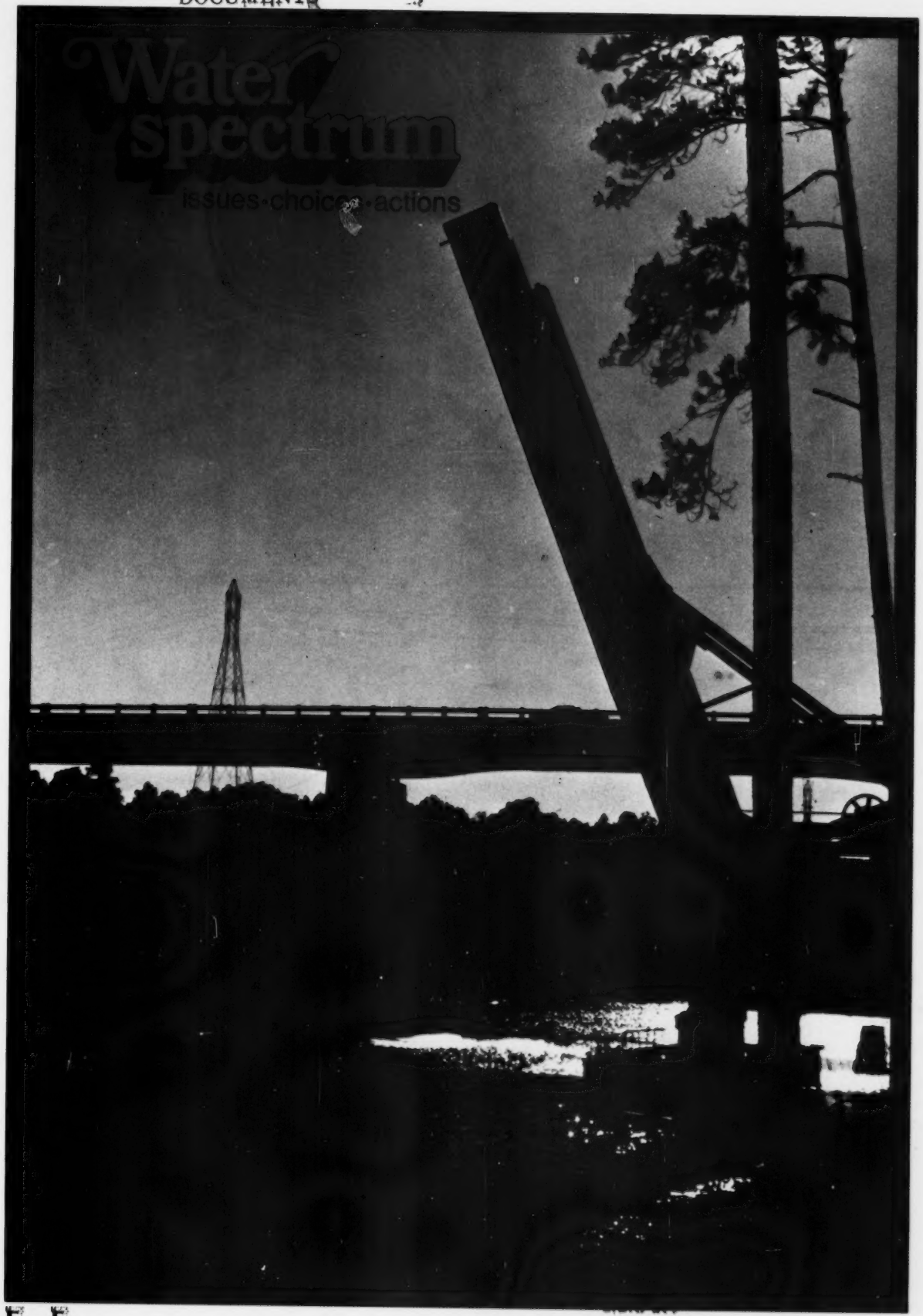
Water spectrum

issues·choices·actions



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Comments on topics in this publication are invited. Send to:
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Address changes: Please attach old address label to request for changes.

COVER: This permanently raised bascule bridge and its replacement symbolize changes along the Intracoastal Waterway. See page 37.

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WATER RENOVATION for unrestricted re-use

by T.D. Hinesly
Scientific Advisor, Civil Functions
Office of the Undersecretary of the Army

The author describes a wastewater recycling system devoid of objectionable features.

He pits land treatment and water re-use against traditional disposal of wastewater into the Nation's waterways.

He explains exactly what takes place in the land treatment process, giving communities a scientific basis for determining which choice is best.

This sign on the Potomac, notifying visitors that the stream contains harmful bacteria and viruses, would be applicable for many major rivers of the Nation.

The land treatment system for renovating municipal and industrial wastewaters is not sewage spreading, sewage farming, disposal of partially treated effluents on land or even the utilization of effluents for irrigation of crops. Many proponents of wastewater recycling contribute to confusion by attempting to analogize between *land treatment* and one or more methods of *disposal* or *utilization*. While wastewater disposal and utilization projects may provide some information which can be extrapolated or interpolated to predict the performance of land treatment systems, they are not directly comparable.

There are many examples world-wide where raw sewage has been continuously and successfully applied on particular sites for periods approaching 75 to over

The water percolates to the water table along flow paths considerably longer than the straight line distance between the soil surface and subterranean drain tiles, where the renovated water is collected for unrestricted re-use.

Dr. Hinesly is a soil ecologist on leave for one year from the University of Illinois.

100 years. The crops grown vary from strictly forage for animals to vegetables for direct human consumption. Other than obnoxious odors there have been few reported adverse changes in the local environments resulting from well managed sewage farm operations. These are excellent examples of the tremendous capacity of soils to attenuate gross amounts of pollutants when properly managed. Proper management is a prerequisite of success because raw municipal sewage may contain from less than 100 ppm (parts per million) of BOD (biochemical oxygen demand) to as much as 500 to 600 ppm, depending on industrial and storm water discharges and infiltration of ground water into sewers. It is not uncommon for the BOD content to vary over this range of values in a 24 hour period. Such wide variations cause difficulties in adjusting rates of application on land areas without creating problems. Sewage farms have been continuously operated for long periods of time by dedicated attention to detailed management schemes and their success must be judged in terms of what they were designed to do. They were not designed to renovate wastewater for unrestricted re-use.

Proponents of waste recycling also often point to many examples where partially treated wastewater has been used for many years on the same land to irrigate crops. Often the wastewater only receives primary treatment to reduce gross amounts of pollutants in the raw sewage. Primary treatment consisting of grinding, skimming, and sedimentation generally reduces the suspended solids and BOD by 50 to 60 percent and 30 to 40 percent respectively of that contained in the original sewage. For the most part, these primary treated effluents have been used to irrigate crop land in order to avoid further treatment which would allow discharge into intermittently flowing streams or streams in which the effluent itself would constitute the major portion of flow. Crop and soil management practices are usually given little weight where the main purpose of irrigation is disposal.

In water short regions, there are many examples where secondary effluents have been used to irrigate crops, parks, and golf courses at rates just sufficient to maintain good growth of vegetation. Effluents from secondary treatment plants or lagoons contain only a small fraction of the BOD originally present in raw sewage and can be applied on land by ordinary methods of irrigation. In secondary treatment plants or lagoons, large quantities of oxygen are supplied in primary effluents to stimulate the growth of aerobic microorganisms. The aerobic microorganisms assimilate and decompose soluble and suspended organic substances. By the removal of dead and living microbial cells by sedimentation, 80 to 90 percent of the BOD originally contained in sewage is also removed. Thus, from sewage having an average BOD load of 200 ppm, secondary effluents will contain 20 to 40 ppm of BOD.

On the other hand, effluents from secondary treatment facilities usually contain about 80 percent of the nitrogen, 70 percent of the phosphorus, 90 percent of the potassium, and 20 to 40 percent of the trace elements which were present in the original sewage. Because of its content of nutrients, when secondary effluents are discharged into streams, excessive growth of aquatic plants is often the end result. The annual excessive growth of aquatic plants and the oxygen consuming processes of residue decay often lead to a deterioration of stream water quality. In view of the deteriorating effect that secondary effluents may have on water quality when discharged into surface waters, it is now a national goal to provide tertiary treatment for, and nutrient removal from, all municipal and industrial wastewaters. But dependable, practical technology for achieving tertiary treatment and nutrient removal in strictly engineered systems does not exist.

Therefore, many people have proposed that soils and their biological systems be used to provide tertiary treatment and nutrient removal. Advocates of the use of land treatment systems for renovating wastewaters point to numerous examples where crop plants have responded more favorably to the use of secondary effluent for supplemental irrigation than to equivalent amounts of irrigation water from other sources. However, the main objective in each case was to utilize the wastewater to grow the crops. Thus, findings from these projects are not directly applicable to a situation where the crops are grown to serve as part of the system for renovating wastewater. Where crops are used in land treatment systems, the aim is to apply as much wastewater as possible without decreasing plant growth.

The three distinct types of land treatment systems are *overland flow, rapid infiltration/percolation* and *crop irrigation.*

An *overland flow* land treatment system is used for soils with very low infiltration and/or percolation capacities. Wastewater renovation by the overland flow system requires the filtering action of a close growing vegetation, generally adaptable grasses, and the controlled flow of a thin film of wastewater over the soil surface to maximize re-activity between the wastewater pollutants and soil microbiological and physical-chemical processes at the soil/water interface.

Rapid *infiltration/percolation* systems are used where deep permeable soil materials are available. The rapid infiltration/percolation basins renovate a few to several hundred feet of water per year by proper management. Proper management implies alternating flooding and drying periods to manipulate the soil microbiological mass, promoting nitrification and denitrification processes and the decomposition of organic materials filtered out of the wastewater at the soil surface. Degrading accumulated organic materials by aerobic microorganisms during the drying cycle facilitates restoration of the water infiltration capacity of the soil filter. Sometimes, grass is grown in the basins to aid in maintaining infiltration capacities during the flooding cycle.

The *crop irrigation* land treatment system may embody various methods of applying secondary treated effluents by spray applications or flooding on land through furrows or borders. Since the main objective is to renovate wastewater for reuse, maximum amounts of

wastewater that are consistent with maximum crop yields are applied.

Many people are distressed by the thought of water reuse. Yet many cities withdrawing stream water for drinking water supplies are taking in some water which previously flowed in upstream city sewers. Several years ago, a sampling of city supplies showed that 2.4 percent of the average water supply withdrawn from streams at low flow stage consisted of prior discharge from upstream municipal sewers. Short term usage of water containing 18 to 50 percent effluent from a neighboring upstream city has been reported. Experts have estimated that 40 percent of the U.S. water supply contains some proportion of water that was used previously for domestic or industrial purposes at some point upstream. In the Ohio River region, 1/6 of the water withdrawn during low flows at Cincinnati was also used before. Combining this knowledge with the fact that few larger cities provide secondary treatment for all dry-weather flows, and practically none can provide treatment for all storm waters, one must put a lot of faith in water treatment plant operators.

Land treatment systems are being planned to apply previously treated wastewater at a quality level at least comparable to and, in many cases, higher than that discharged into some municipal water supply sources. *The possibility of using the land treatment system for renovating treated wastewater to drinking water quality is greater than can be provided by water treatment plants.*

Water treatment processes generally include coagulation and sedimentation followed by slow or rapid sand filtration. The water is then chlorinated and pumped into the water supply system. Since water treatment plant operators do not optimize the use of biological systems, they must periodically wash or backflush accumulated materials from surface pore spaces of sand filtration units to restore their infiltration capacities. The organic and mineral pollutants removed are usually discharged back to water courses or to sewers.

In land treatment systems the pollutants are filtered out in the soil surface where a host of beneficial soil microorganisms assimilate or convert organic substances to innoxious forms. Inorganic substances are converted to sparingly soluble compounds and some are utilized as nutrients by green plants. In the case of the irrigation land treatment system, large supplies of inorganic chemical elements are removed as normal constituents of harvested crops. Some inorganic chemical elements adsorbed in relatively large amounts by plants are hardly reduced in levels of concentration by typical water treatment processes.

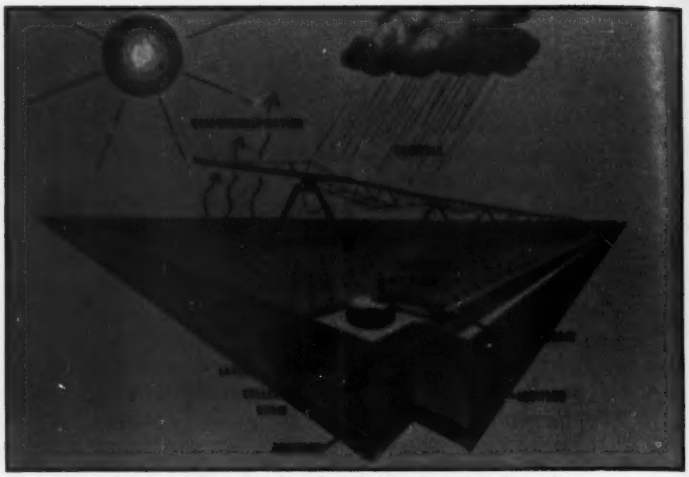
Space limitations prohibit a full discussion of all land treatment systems. Therefore, the remainder of this article will contain comments in regard to spray irrigation only. Spray irrigation land treatment has the greatest applicability to different soil types and cultural practices. This treatment may be used on varying terrain, requires less land preparation, and is less labor-intensive when compared to other methods of irrigation. As wastewater quantities increase in a particular region, spray irrigation systems are easily expanded to cover greater areas. Maximum benefits are realized from the plant and animal nutrients recycled in growing plants, which is a most important reason for choosing irrigation over other land treatment systems where it is possible to do so. Many of these nutrient elements are becoming increasingly scarce and more costly to replace in soils.

Although soils have varying capacities to remove water contaminants by filtering, adsorption, exchange and precipitation, their effectiveness in water renovation is largely determined by the ability of microorganisms populating the first few feet of soil depth to convert the contaminants into innocuous volatile substances, into forms utilized by higher plants and to incorporate part of the materials into new protoplasm. Under favorable conditions many water pollutants are more or less permanently stored in the soil as constituents of refractory organic and sparingly soluble inorganic compounds.

Waste materials supplied in concentrations inhabiting the growth of microorganisms, either directly as a toxicant or indirectly by adversely altering favorable soil chemical and physical properties, reduce the soil's capacity to attenuate water pollutants. Once wastewater contaminants migrate below the biologically active root zone of plants, their removal is mainly by adsorption and chemical precipitation reactions. Some chemical reactions are exceedingly slow, permitting contaminants to travel long distances as constituents of water moving through geological materials in response to a pressure gradient.

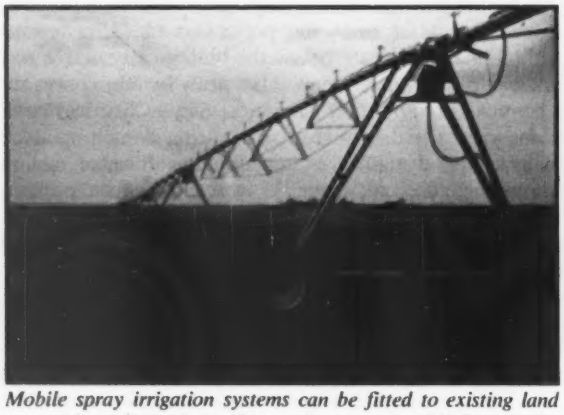
Contamination of underground water supplies can be traced to situations where polluted water has been either injected directly below or has been allowed to circumvent the biologically active soil surface. Circumvention cannot occur as long as the water must move under tension for some distance before it reaches the water table. The passage of water pollutant substances through soil surface materials results when systems are overloaded to the extent that the aerobic zone is eliminated. If soil systems are used for renovating wastewater, plans must include management practices optimizing conditions for maintaining mixed cultures of microorganisms and combinations of higher plants which consume waste by their multiplicity of metabolic processes. In this respect, the necessity of establishing a well designed soil drainage system cannot be over emphasized.

Maintaining a water unsaturated, aerobic zone in the soil surface insures more complete filtering and adsorbing of wastewater pollutants. The water moves downward in the unsaturated zone under tension, insuring intimate contact between wastewater pollutants and reactive sites on soil organic and mineral particles. *Four or five feet of water unsaturated soil appears to be as effective in filtering chemical pollutants and pathogenic organisms (including viruses) as several hundred feet of water saturated soil material.* Furthermore, microbial

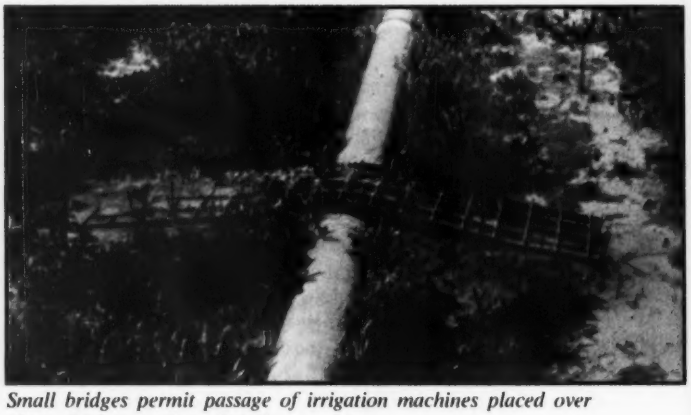


The soil surface contains microbes that decompose organic and biological pollutants as they are filtered out. Many inorganic chemical pollutants are converted into sparingly soluble compounds.

Left-Viruses and other pollutants are removed by filtration through at least five feet of water-unsaturated soil and destroyed by biological activity near the surface.



Mobile spray irrigation systems can be fitted to existing land uses without disrupting utility services or ownership boundaries.

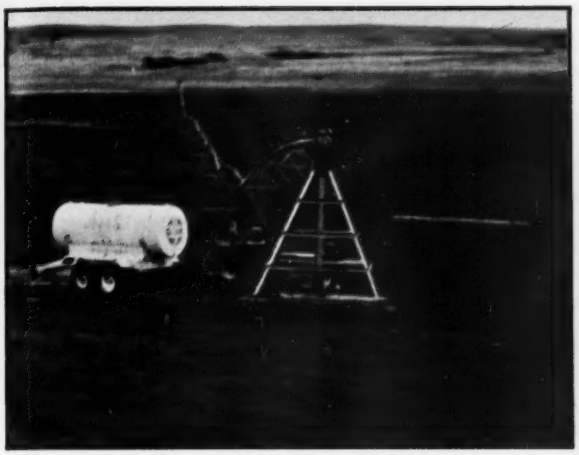


Small bridges permit passage of irrigation machines placed over pipes, ditches or other obstacles.

degradation of organic constituents filtered from wastewater is more rapid and complete under aerobic conditions than under prolonged anaerobic conditions.

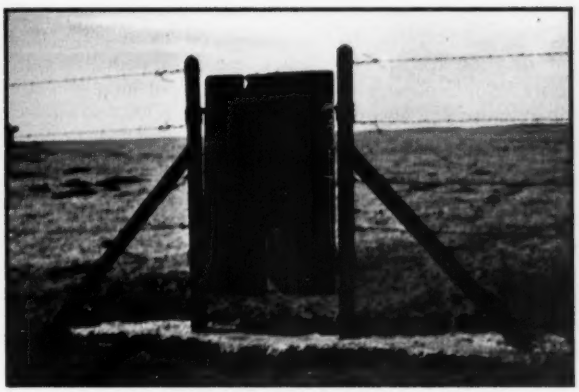
Unless the water unsaturated zone is sufficiently deep, the exchange of gases with the aerial atmosphere through open pathways or pores in the soil matrix is restricted. Like animals, plant roots and soil microorganisms respire, consuming oxygen and releasing carbon dioxide. When too many soil pores fill with water, the rate of diffusion of oxygen to and carbon dioxide away from roots may be reduced to levels inhibiting normal plant growth. Plant roots suffering oxygen deficiency cannot absorb the moisture and nutrients required to support normal growth of above ground portions of plants. It follows that maximum crop yields can not be obtained and thus the crop's potential to remove nitrogen and other nutrient elements from wastewater will not be realized.

From what has been said it should be clear that the most important aspect of establishing a spray irrigation land treatment system is to select a proper site.



Effluent can also be spray irrigated on rolling lands, but runoff controls are needed to minimize erosion.

Level ridge terraces containing surface inlet pipes trap pollution bearing sediment on the field but permit control over runoff of surface water for release or further treatment.



Irrigation towers can cross fence lines through swinging gates or cattle guards in order to supply water to adjoining lands owned by more than one participating farmer.

A minimal change to existing landscape features easily fits irrigation machines to lands already under cultivation.

Wherever possible the site should be selected so that the frequencies and rates of water applications will be limited by the soil's capacity to filter, absorb, and precipitate pollutants, rather than by soil hydraulic characteristics. *The primary or short term limitation on wastewater applications should be the ability to manage cropping systems for nitrogen removal.* If soil hydraulic characteristics limit wastewater application rates below levels required to furnish nitrogen for maximum crop yields the requirements for land area is increased for renovating a specific annual flow of wastewater. Consequently, additional cost for providing irrigation equipment to apply less wastewater and soil drainage works over larger areas is imposed on land treatment systems. Therefore, when the main objective is water renovation, sites should be avoided where the first factor limiting wastewater loading rates is the soils capacity to accept water.

In view of the economical advantages of selecting soils with rapid to moderate infiltration and percolation capacities, many of the soil types selected for land treatment systems are likely to be those on which agricultural

production, even in the humid eastern regions, is limited by drought periods during the growth season. It is difficult to estimate the value of the wastewater supplied to the participating farmer. Reported yield increases resulting from supplemental irrigation of various crops are generally those obtained by optimum levels of water application. The optimum level is generally determined by equating the incremental costs and returns associated with incremental yield increases resulting from incremental applications of water. Since cost for wastewater applications will be borne by the wastewater treatment entity, the participating farmer will not be concerned with optimizing water use. Rather he will be concerned with maximizing yields with maximum amounts of water.

The successful operation of a land treatment system is dependent upon the types of vegetation and cultural practices employed, especially where nitrogen is the first limiting factor on wastewater loading rates. A broad range of different kinds of vegetative cover is available. From a strictly water treatment standpoint, grass crops like Reed Canary and Coastal Burmuda would be ideal vegetative covers in certain climatic regions. Grasses simplify the land treatment system's management and operational requirements and minimize the acreage required to renovate a specific volume of wastewater. However, before markets could be developed for several thousand to several hundred thousand acres of grass a considerable investment in dehydrating and pelletizing equipment would be required. But more important, such a single cropping system would disrupt local agri-business concerns. On the other hand, if the cropping system includes as many acres of crops as the participating farmers would plant in response to normal market conditions, opportunities for expansion will exist for all agri-business concerns. One possible exception is those concerns which are engaged mainly in selling inorganic fertilizers.

There appears to be no reason to expect that present cropping systems would need to be changed except to incorporate some soil and water conservation practices. The practices needed to assure water renovation are familiar to farmers but have not appeared profitable enough to prompt widespread adoption. For example, winter cover crops may need to be interseeded in cash grain crops to remove nitrogen from wastewater applied after the cash crop has reached maturity.

Winter cover crops resuming growth in the early spring would absorb additional quantities of nitrogen from applied wastewater until the next succeeding cash crop is planted. In some cases, it may be desirable to kill the cover crop with a contact herbicide and plant the cash crop in tilled strips through the surface mulch or use a no-till planter. Additional nitrogen can be immobilized by soil microorganisms decomposing residues of cash and cover crops returned to the soil surface in the fall and early spring seasons. Just how much nitrogen will be temporarily immobilized depends on the amount of carbon and nitrogen in the residues and their lignin content. But at any rate, nitrogen from the applied wastewater must be conserved from the fall and early spring wastewater applications for later release by microbial mineralization processes. The stored nitrogen must be released at a time when the cash crops is sufficiently established to utilize it and thus prevent its leaching to depths below the root zone. During peak nitrogen absorption periods several crop species require the nutrient element in amounts wastewater applications cannot supply. *Maximum yields cannot be realized unless recycled nitrogen is released by soil microbes from the residues during peak crop demands.*

Wastewater, equivalent to secondary effluent, contains total nitrogen contents in the neighborhood of 16 to 24 ppm. This amounts to about 3.5 to slightly more than 5 pounds of nitrogen per acre per inch application of wastewater. Thirty percent of the nitrogen may be volatilized by ammonium nitrogen evaporation from the soil surface and nitrification/denitrification processes. Five percent may be incorporated in organic forms which resist microbial decomposition. As much as 10 percent may be transported below the root zone. Slightly more than 2 pounds of nitrogen per acre inch application remains for absorption by crop roots.

During peak nitrogen absorption periods, a crop like corn may require 4 to 5 pounds of nitrogen per acre per day. In humid areas, it is unlikely that an inch of wastewater per day can be applied to growing crops during peak nitrogen demand periods. Thus, maximum crop yields cannot be obtained without the timely mineralization of nitrogen previously absorbed by cover crops and immobilized by soil microbes during the early phases of plant residue decomposition processes. During the peak growing period in early spring, many winter cover crops will absorb as much as 2 pounds of nitrogen per acre per day. As the dead cover crop is decomposed some of this nitrogen will be released in forms available to the established cash crop, at a time when sufficient amounts cannot be supplied as a constituent of wastewater.

Each inch application of treated wastewater also supplies 2 to 3 pounds of soluble potassium per acre. In managing nitrogen with cash and cover crop residues, potassium is automatically conserved in the soil surface. The available potassium in surface soils increases with continuous use of the land treatment site.

Whereas the nitrogen content may limit applications during a single irrigation season, the phosphorus supplied in wastewater and accumulated in soils will eventually determine the continued usefulness of a particular site for wastewater renovation. owever, the phosphorus accumulation in soils will not adversely affect soil productivity—on the contrary, its fertility will be much improved. Treated wastewater may contain from 10 to 25 ppm of soluble phosphorus as PO^4 and, thus, would supply 0.6 to 1.5 pounds of elemental phosphorus per acre per inch application.

The concentration of phosphorus in normal soil

solutions is usually less than 0.1 and seldom greater than 1 ppm. Therefore, the soluble phosphorus, entering the soil as a constituent of wastewater, will greatly exceed the equilibrium value of soil solutions. When the equilibrium of the soil system is destroyed, some phosphorus is adsorbed on the surfaces of soil particles such as clay, calcium carbonate, and aluminum and iron minerals or precipitates. Initially, the phosphorus adsorbed on the surfaces of soil particles can re-enter the soil solution by iso-ionic exchange over some time span. At any given time, concentration of phosphorus in the soil solution will depend on the amount of inorganic phosphorus in the wastewater and the size of the soil's adsorption system. With continued wastewater applications the phosphorus concentration will increase in soil solutions until it precipitates to form a sparingly soluble compound. The ultimate phosphorus content in the soil solution will finally be determined by the solubility product of some precipitate.

For planning purposes, it is possible to estimate the effective life of the soil system to remove phosphorus from percolating wastewater by determining the soil's phosphorus adsorption capacity and the flow path distance. Much of the wastewater infiltrating the soil surface and eventually removed as renovated water by a tile drainage system, traverses a flow path distance that is considerably greater than the average 5 foot depth of water unsaturated soil that should be maintained. The flow path distance for the major portion of the water depends on the depth and spacing of tile drains and the depth to an impermeable layer of geological material. For this reason phosphorus adsorption in the water saturated zone must be taken into account.

Soils have demonstrated capacities to absorb and convert to sparingly soluble forms hundreds to several thousands of pounds of phosphorus per foot depth. Some phosphorus is removed from the soil as a constituent of the harvested crop. But amounts removed by harvesting crops are so small they are usually ignored in estimating the effective life of a land treatment system.

Many are concerned that maximizing water applications will lead to increased soil erosion problems on sloping lands. But the same crop and soil management practices effective in controlling soil erosion will apply during wastewater renovation. In some cases, erosion control structures and adaptable minimum tillage practices will be required. To keep sediments on the field, level ridge surface inlet terraces are effective. The surface inlets are above ground slotted pipes, located in a depression behind the terraces, which serve as outlets for a stilling basin. After the sediments are deposited around the inlet pipes, water is conducted to underground tubes or tiles which transmit the runoff water to outlets. Except possibly for the nitrate form of nitrogen, retention of sediments on the field will insure retention of major water pollutants. Since overland flow through grass is an effective means of removing all forms of nitrogen from water, it is unlikely that runoff waters will contain unacceptable concentrations of nitrate nitrogen if cover crops are maintained.

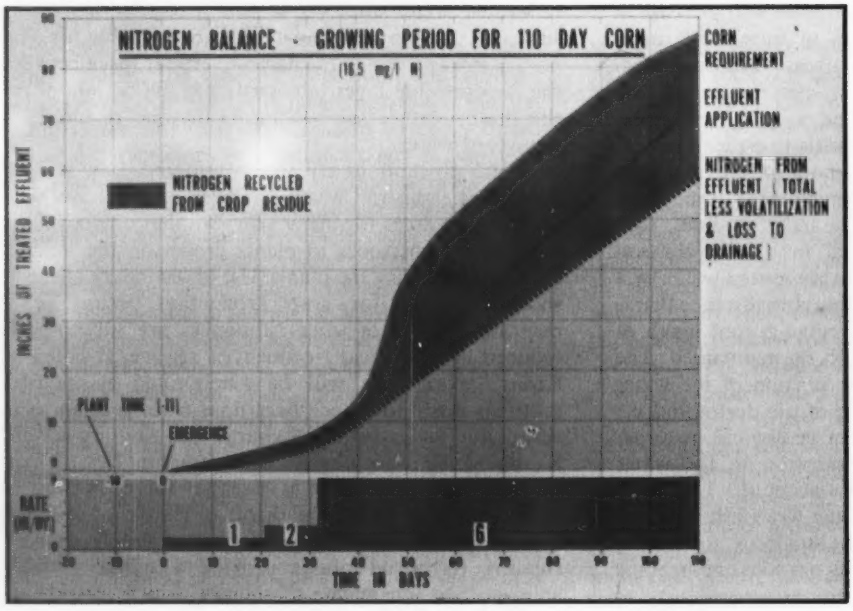
There is also concern about increasing flood hazards in the land treatment site area. But the system is designed for complete control of both surface and drainage waters. Flooding will not be a problem on properly selected sites, preferably at the head of a drainage basin. Water can, in many places, be held below surface until it is needed for low flow augmentation. During dry seasons, the water table can be sufficiently lowered by pumping shallow wells to accommodate the storage of renovated water and wet season precipitation. Where sufficient underground capacity is not available for temporary storage, due to the narrow vertical space between the impermeable layer (aquitard) and the bottom of the tile drain, surface impoundments may be required for renovated water.

Health precautions are also considered. Raw sewage, containing industrial waste, has been continuously used on the same areas for many years without obvious harm from trace substances to plants grown on the land or animals consuming the plants. Use of secondary effluents should be safe for crop production because concentration levels of trace substances are substantially reduced by biological treatment of sewage. If potential hazards exist, they will be ameliorated as industry pretreats waste to reduce hazardous trace substances to acceptable levels before discharge into sanitary sewers. It should be remembered that pretreatment for application on land is not as essential for protection of human health as it is for direct discharge of effluents into streams serving as drinking water supply sources. Healthy terrestrial plants provide a buffer between animals and chemical substances which could accumulate in soils as a result of wastewater irrigation. Few inorganic chemical elements are absorbed and accumulated in excessive amounts provided crop plants are presented with a balanced supply of nutrients and an adequate growth environment. Nutrient balance is more important than total amounts added to soils. Abnormally high concentration levels of an inorganic chemical element in crop plant tissues are usually traceable to one

or more of the following factors: a nutrient deficiency, moisture stress, adverse soil pH, poor soil drainage, disease and/or insect damage.

Normal concentration levels in crop plants vary widely between plant species and within varieties of a single species. Variation between different varieties is wide enough to encourage selection or development of crop plants resistant to the uptake of chemical elements above acceptable concentration levels.

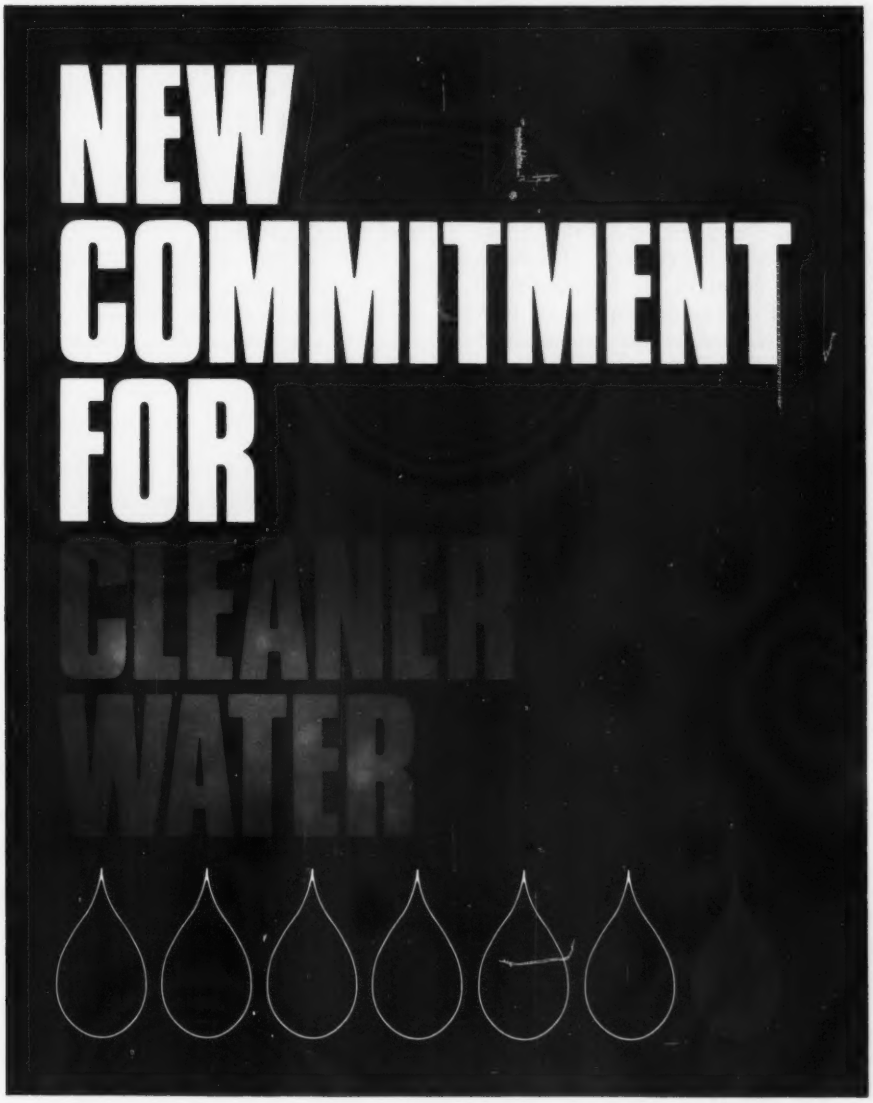
Winter cover crops reduce erosion, maintain rapid infiltration of water, and adsorb nitrogen and other plant nutrients for later use. The stored plant nutrients are released by soil microorganisms the following spring as needed to supplement nitrogen supplied through spray irrigation during the peak demand by cash grain crops.



Many people are concerned about spreading pathogenic microorganisms during the spray applications of treated wastewater on land. Their fears are largely stimulated by the fact that chemical disinfection seldom destroys all pathogens, especially more resistant viruses. Some believe surviving viruses could be transported downwind within small droplets of water. Since uncertainty persists about possible dangers of applying disinfected secondary effluents, precautions should be taken. During winter months, treated effluents will, of course, be stored for 2 to 5 months, depending on geographical location. Viruses do not remain viable outside a susceptible host for long and soon die-away to low concentration levels during storage.

To cope with the potential presence of pathogens, each lagoon storage facility could be divided into cells. Only water stored longer than the die-away period would be released for spray irrigation. Center pivot irrigation machines directing effluent in a downward trajectory—to prevent wind drift—are also being developed. Other modifications of irrigation and ancillary equipment are being researched.

Since the soil's capacity to reduce phosphorus contents to desirable levels will be exceeded at some time, each site will be abandoned eventually. In terms of continued crop production, the site's value will be greater upon abandonment than when it was established. The intervening years will have seen beneficial changes in soil properties induced by wastewater constituents, not to mention the land improvements installed to control erosion and collect the drainage water. Therefore, the land treatment system is the only tertiary and nutrient removal wastewater treatment system which will *appreciate,* rather than depreciate, in value. ■



The Federal Water Pollution Control Act Amendments of 1972 provide a major redirection of the Nation's program for improved water quality. It is based on a strategy for the control of pollution discharged into the navigable waters which substantially departs from the principle of controls followed in previous Federal law. The new law also strengthens and clarifies the role of various Federal agencies and State governments in implementing the water pollution control programs.

by Senator Jennings Randolph
Chairman, Committee on Public Works

This legislation is a strong assertion by the Congress that the general quality of water throughout the United States can no longer be allowed to deteriorate. It reflects our belief that too little attention has been given to maintaining the quality of our water supplies. As with many other of our natural resources, water has been used wastefully in this country. This practice obviously cannot continue and the Congress became aware that previous efforts to preserve and enhance the integrity of our waters were inadequate.

This act is one of the most thoroughly and painstakingly developed measures ever reported by the Senate Public Works Committee. From beginning to end it occupied nearly two years of our time. Thirty-three days of hearings were conducted which resulted in 6,400 pages of testimony and documents. There were 170 witnesses and an additional 470 written statements submitted for the Record. Every detail of the proposal was subjected to extensive discussion in 45 executive sessions of the Subcommittee and Committee. Conferences with members of the House of Representatives extended through 39 meetings.

The stated objective of the new law is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. In reaching this objective, the new law makes it a national goal to eliminate discharge of pollutants into navigable waters by 1985, and to attain by July 1, 1983, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water.

This act rejects the concept that waters may assimilate substantial quantities of waste without affecting some designated beneficial use. It also specifically bans stream-flow augmentation—pollution dilution—as an alternative to adequate waste treatment. Recognition is given, however, to stream-flow augmentation as a useful means of reducing the environmental impact of run-off from non-point sources.

In addition, the act discards as its principal base for enforcement and standard-setting, the stream quality approach taken by the 1965 act which, until last year, had provided the direction of this program. The water quality strategy of the 1965 act imposed the burden of proof on the Government. It had to show that the degree of treatment to which any individual community or industry was willing to commit itself would not produce the desired level of water quality.

The new act establishes a sequential program leading toward the goal of eliminating the discharge of pollutants into the ambient water environment—that is, the recycling of pollutants. Industries must now comply with permits requiring the installation of the best practicable control technology currently available by July 1, 1977. In this same time span, each community must install secondary treatment plants as defined by the administrator of the Environmental Protection Agency. By mid-1983, industries will be required to reach the level of effluent reduction attainable through the application of the best available control technology. This must be done to eliminate discharges of all pollutants where it is technically and economically achievable for a class or category of point sources.

The 1983 standards require reasonable further progress toward the national goal of eliminating the discharge of all pollutants, and are expected to result in a substantial additional investment for most industries which have complied with the 1977 standards.

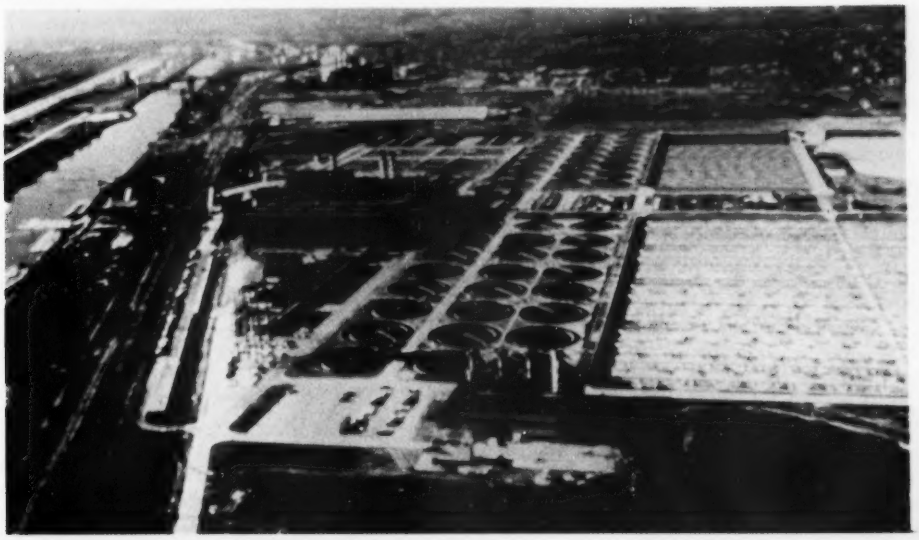
In addition, municipal treatment plants are required by this act to consider and utilize techniques for the recycling of water and the confined and contained disposal of pollutants by mid-1983.

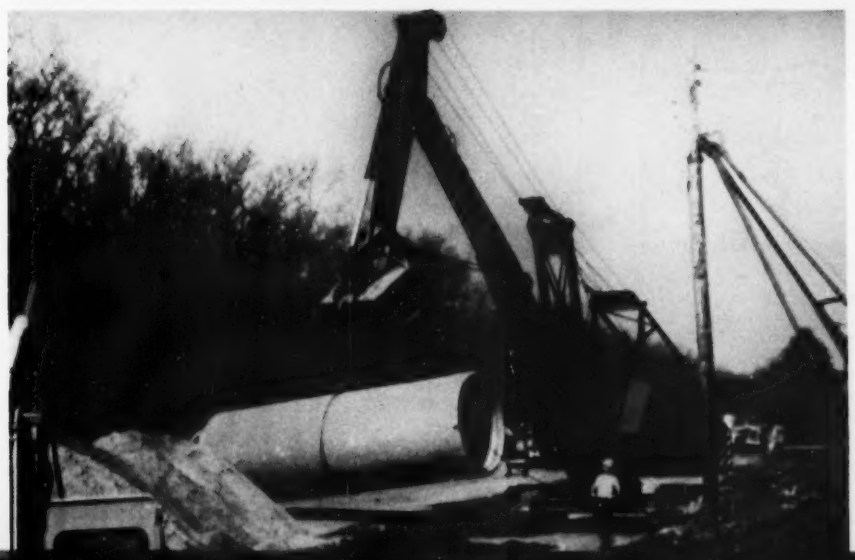
There are a number of advantages to the technological approach which the Congress chose to achieve water quality goals. First, it provides a firm basis against which

Visible pollution, such as this, gave impetus to the Nation's determined commitment for cleaner water.

Photo — Havens and Emerson, Ltd., Cleveland

The act will encourage advanced wastewater treatment facilities along traditional lines where that method appears to be the most feasible.





Center-By 1975, municipal treatment facilities constructed or modified with assistance under this act must consider and use the most practicable waste management techniques, including land treatment.

The act will encourage where practicable, construction of lines and facilities for transferring of wastewater away from waterways.

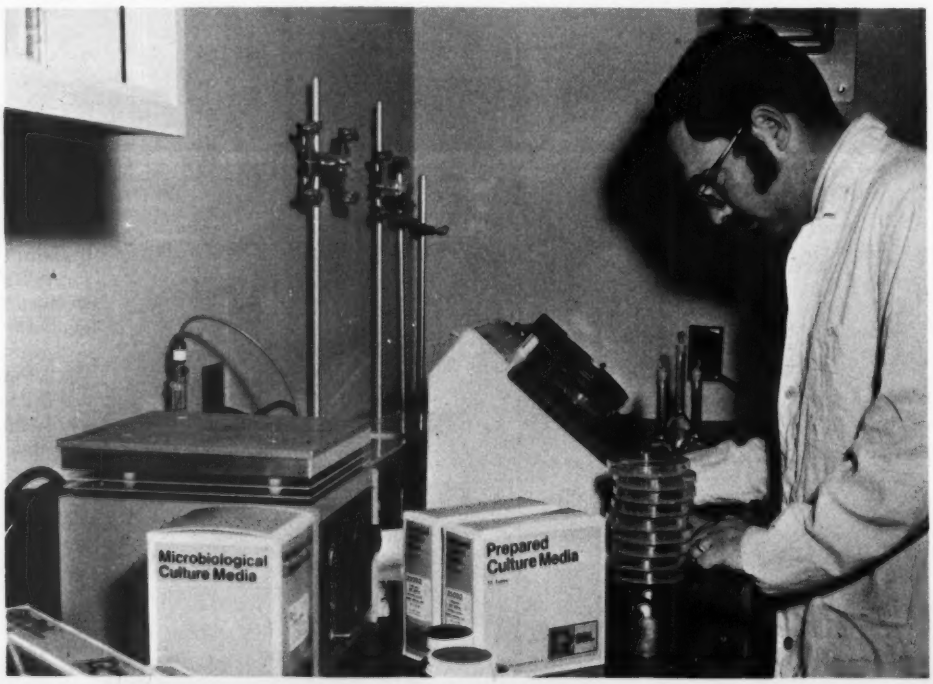
standards of performance can be measured. This approach also utilizes a set of values which can be monitored on a continuous basis, the level of performance which can be effectively enforced, a quantifiable level of discharge whose effect could be evaluated and eventually a measurable improvement in water quality based on known reductions in input. This procedure was not intended to be complicated; it was intended to achieve results which had not been obtained under the 1965 Federal Water Pollution law, and it was intended to achieve a degree of uniformity in controls which would eliminate regional discrimination and improve national water quality.

The 1972 act establishes new directions for Federal involvement in water pollution control. New priorities are congressionally established for the research programs conducted by the section 105d requirements of the act, requiring the administrator to conduct accelerated efforts to develop waste management methods to eliminate the discharge of pollutants, and methods of reclaiming and recycling water and confining pollutants so they will not migrate to cause water or other environmental pollution. *This approach to waste water management is given additional urgency in Title II of the act which deals with grants to public agencies for the construction of sewage treatment works. The act authorizes $18 billion for a three-year period to provide community grants for the construction of sewage treatment facilities. The Federal share of these activities is set at 75 percent. This provision also authorizes grants for the reconstruction of existing sewage collection systems and the installation of new collection systems in existing communities.*

Section 201 of the act requires that waste treatment management plans and practices provide for the application of the best practicable waste treatment technology before any discharge into receiving waters. We include reclamation and recycling of water and confined disposal of pollutants, and the consideration of advanced waste treatment techniques. In the case of municipal sewage treatment facilities constructed or modified with assistance under this act, beginning with the 1975 fiscal year, alternative waste management techniques, including spray irrigation and other land disposal methods, must be considered and utilized where practicable. *One of the principal influences which led the Congress to establish this new policy for the reclamation of water and the confined disposal of pollutants, was the activity of the Corps of Engineers in the Pilot Waste Water Management Program. The feasibility studies conducted by the Corps for regional waste water management systems in the metropolitan areas of Chicago, Detroit, Cleveland, Boston, and the San Francisco Bay, demonstrated to the Committee the possibilities for land treatment and other alternative systems in eliminating the discharge of pollutants into navigable waters.* This work of the Corps of Engineers; together with the area-wide systems for land disposal of municipal wastes now under construction at Muskegon, Mich., persuaded the members of the Senate Public Works Committee that the bill should encourage States and local governments to consider alternative choices for waste water management on a regional basis.

The concept that area-wide waste treatment management providing control or treatment for all point and non-point sources underlies the regulatory mechanisms of the entire act. Section 208 requires that a planning process based on this principle be established in every part of the country. In urban or industrial areas, such area-wide planning will be done by designated local planning agencies. *In areas of States which have not been specially designated under section 208, this planning*

Under provisions of the act, research at all levels is to be directed toward eliminating pollutants.



Each dot represents a wastewater treatment facility in the Chicago vicinity, indicating the complexity of planning regional systems for metropolitan areas. The Corps, which has conducted studies for Chicago and other cities, is authorized to provide technical assistance on area-wide waste treatment when requested by States, cities and other levels of government.

must be conducted by the State. It is in this enterprise of area-wide waste management planning that the Corps of Engineers is given its most important responsibilities under this legislation.

Because of its experience with the Pilot Waste Water Management Program, as well as its considerable expertise in planning functions built up over the years, *the Congress authorized the Corps of Engineers to provide consultation and technical assistance to any State or designated planning agency in developing and operating its continuing area-wide waste treatment planning process.*[1] The Corps of Engineers will be expected to make its planning assistance available on the request of the government or the designated planning organization. The new law authorizes $50 million in each of the two fiscal years 1973 and 1974 to carry out this responsibility.

The Corps of Engineers is given a major responsibility to develop and test procedures for correcting one of our most serious water quality situations, the pollution of the Great Lakes. Lake Erie was chosen as the testing ground in this project and the Corps will design the waste water management program intended to achieve the environmental repair of Lake Erie.

[1]Also, as a result of the Pilot Wastewater Management Program, Congress has authorized the Corps of Engineers to undertake a program involving comprehensive planning for all water resource activities in urban areas. This program, which includes wastewater planning, is termed Urban Studies. It began in FY 73 with studies of the following seventeen urban areas: Omaha, St. Louis, Kansas City, Duluth-Superior, Spokane, Boise, Seattle, Denver, The Colorado River Basin in Texas, Binghamton, N.Y., Atlanta, New Orleans, Northwest Florida, Pine Bluff, Ark., San Juan, P.R., Christina River Basin in Delaware, and the Chester Creek Basin in Pennsylvania. Nine additional studies are included in the FY 74 Civil Works budget.

A stocking of lake water here with fingerlings symbolizes a water quality goal, one that will make waters nationwide more habitable for fish.

The Corps retains its authority of matters relating to navigation. Although a comprehensive system of permits is established under this act, the Corps will continue to be the issuing agency for permits for dredging and for the building of structures in navigable waters.

In developing this legislation, the Congress was aware that both in philosophical approach and specific requirements we were moving in new and untried directions. We knew that the activities mandated by the act would require scrutiny so that we could assess their effectiveness. For this purpose the act authorized the establishment of the National Study Commission with a mandate to carry out independent evaluations of the economic, social, and environmental implications of the legislation's regulatory features. The commission will examine implications of the long-range goals of this act and will permit the Congress, in the mid-1970s, to determine if we are moving in the right direction.

Assured supplies of water and uncontaminated water are essential to the continued prosperity of our country and the well-being of its people. The Water Pollution Control Act Amendments of 1972 represents the most significant commitment ever made by the Federal Government to clean water. Its requirements are stringent, but I believe that they are reasonable and can be effective in achieving the long-range goals we have established. ■

RECREATION

"At Corps recreation areas the surging demand for service, facilities and space has jumped 17 fold in 20 years."

If satellite imagery could give us a three-dimensional view of what's going on at all the Nation's recreation sites on a peak day, perhaps we could truly grasp the almost inconceivable magnitude of the business. As it is, we grapple with unwieldly data, each of us interpreting numbers in differing fashion.

To me, and I'm sure to many others, such figures as a 300 million annual attendance at Corps recreation areas —which we operate directly or lease—leaves me wanting a more comprehendible description. I begin to think of the 10 million acres of Corps land and water that people can go to, of the 390 Corps lake projects that have heavy recreation use. Even these figures are a bit overwhelming, but they are realistic enough that I can envisage the managers of these sites watching the tides of people coming in every weekend. I can also sense the urgency of the managers' actions in trying to keep ahead of the public's demand for services and facilities and space.

I too feel this urgency, but not everyone shares such a concern about recreation. Some, for reasons of their own, oppose any form of a recreation program. For instance, a recent *Water Spectrum* article on recreation brought a reader reaction that "all forms of recreation are positively harmful." He contended that "what this country needs is more people who work, not spend their time in leisure."

A somewhat opposite view, which serves as a basic reference for current recreation programs, was expressed over 10 years ago by the Outdoor Recreation Resources Review Commission (ORRRC). Its report emphasizes that "an American looks for meaning . . . of his past not in ancient ruins but more likely in mountains and forests, by a river or at the edge of the sea." It goes on to observe that "from the beginning, one of the strongest currents in American thought has been the idea that the outdoors is a *right* of Americans—not only to be enjoyed but vital to our *spirit.*"

The commission recommended this: "It shall be the national policy, through the conservation and wise use of resources, to preserve, develop and make accessible to all American people such quantity and quality of outdoor recreation as will be necessary and desirable for individual enjoyment and to assure the physical, cultural and spiritual benefits of outdoor recreation."

Since the ORRRC recommendation, Congress has responded by passing a comprehensive set of legislation to insure future recreation opportunities for the public.

Still, from time to time opposition to recreation is voiced; but such views won't alter facts. Opposition to recreation programs won't reduce the demands of those seeking recreation. Views that people should stay home and watch TV over the weekends won't keep them there. Too many millions want to get out, get near the water.

The results from the early ORRRC report highlighted this fact. They reported even then that "the demand is surging. . . . By 2000 the population should double; the demand for recreation should triple." The current participation reveals a society seemingly out to fulfill this prediction.

The ORRRC report also stated that "water is a focal point of outdoor recreation." That's why, moreover, the Corps finds itself in the recreation business. It has the water. The Corps manages the largest water resource program in the Nation. Even though recreation may not be at the top of the list of reasons why Corps projects came into being, in terms of current operation and maintenance functions at a large number of lakes, it's shifting closer to the top.

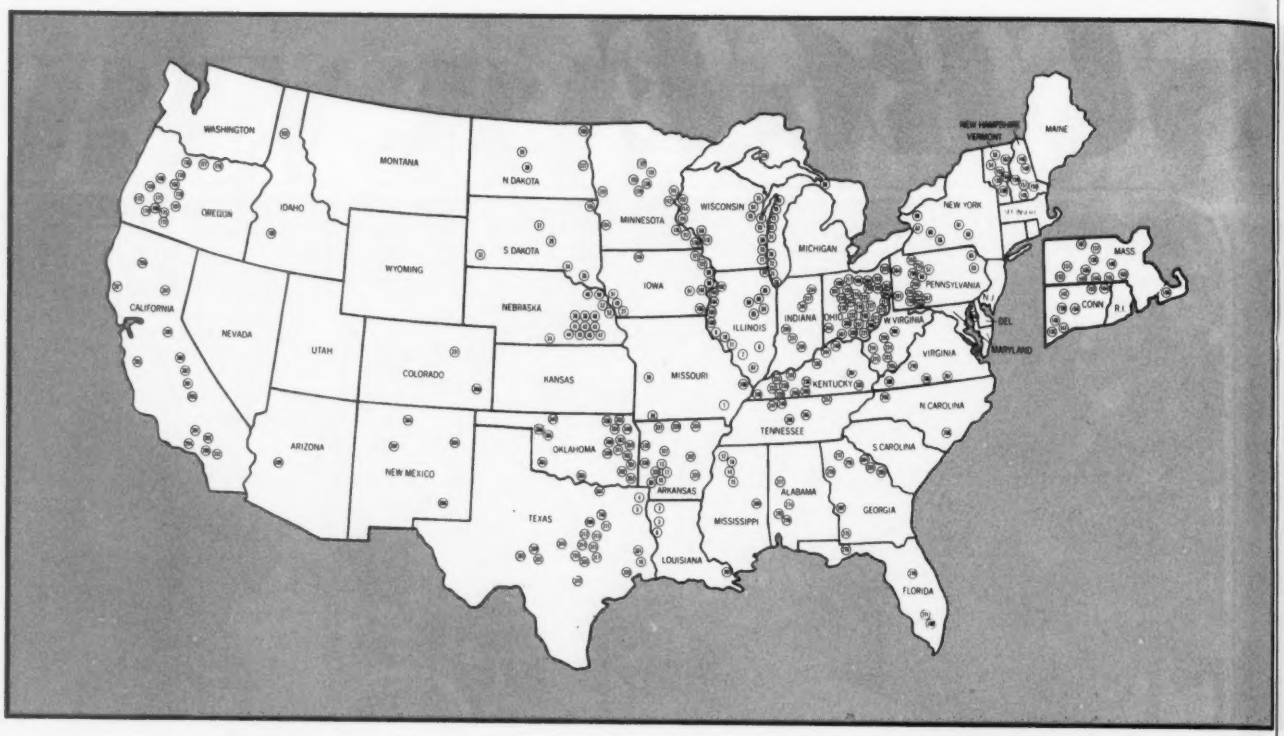
Over the past 30 years recreation at Corps-built lakes and waterways has grown from an incidental amenity to a major program that caters to the needs of millions of leisure-seeking people. *In just 20 years, attendance at Corps lakes has increased 17 fold—over twice as fast as the number of lakes.* People converge on water areas not only for boating, fishing, skiing, swimming and other water fun, but for picnicking and sightseeing, hiking, group games and the like. During the past decade they have converged at the increasing rate of 10 percent a year.

This increase at Corps lakes is part of a national expansion in the recreation business, and that business is measured in the *billions* of dollars. The total tourism industry in terms of dollars spent in the U.S., as brought out in hearings before the subcommittee on environmental problems affecting small business, amounts to between $50 and $70 *billion* annually. What this generates as jobs and increased profits for small business as well as industrial firms, as estimated at the same hearings, is an additional $100 to $140 *billion* in economic activity.

A point of significance is that this vast sum passing through the hands of job holders, small businessmen and others is attributable in part to the recreation areas operated by public agencies. These agencies actually furnish the base for the recreation industry, a major section

SURGE

by Maj. Gen J. W. Morris



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of the Nation's economic vitality. Without that base of public lakes and camping sites and facilities for recreationists to go to, the multibillion dollar recreation business in its present form could not exist.

The Congress has recognized the national and local economic values of the recreation business and is beginning to appropriate funds as a national *investment* rather than viewing the amounts only as an expenditure. Even though these investments have obviously brought returns far greater than amounts expended, the funds available have not been enough to generate the maximum economic activity nor is there enough to keep pace with the public's recreation needs.

The latter is of the most immediate importance—particularly for children, the aged, others who prefer land activities, and the handicapped who have every right to enjoy recreation areas, yet require specially designed facilities. For instance, people in wheel chairs should be able to read bulletin boards at eye level, nature trails and other scenes should have descriptive matter in braille, children too young to venture into lake waters should have access to wading pools, the aged should have access to comfortable seats that overlook both quiet and active scenes. These are only surface examples. *The real needs are in the full range of non-water recreation opportunities* because it is here that services and facilities are the shortest. *Water draws families to the areas; but once there, a few people go to the beaches or out in boats part of the time while the great majority is engaged primarily in non-water pursuits.*

All these needs, like siphon hoses, attempt to draw from the very limited amount of available funds. And the trickle of money gets siphoned off long before it can reach vital sections of the recreation field. Thus the matter of meeting future recreation needs depends on a better funding formula, whether a single source or some combination of fees and appropriations from all levels of government.

The strongest incentive for coming up with that formula is, in some ways, negative: it is recognition that conditions will not remain static. It is recognition that higher funding will be needed just to keep this large part of the Nation's recreation base in a healthy and usable condition.

Congress identified the value of Corps lands and water as an important base as far back as the 1940s. At the same time, Congress recognized that water in itself does not necessarily create a recreational opportunity. For opportunities to exist water must be kept sufficiently clean for reasons of health and aesthetic appeal. They had in mind that facilities provided for health and safety needed to be adequate and well maintained. Added to that, a most important feature has been their recognition that places which offer recreation for people must be preserved and cared for and not be damaged through neglect or overcrowding.

Congress specifically authorized Corps recreation management under Section 4 of the 1944 Flood Control Act. This act recognized the potential of water resource projects in providing outdoor recreational experiences and gave the general authority to assist and sustain public outdoor recreation. The act has this provision:

> "the Chief of Engineers . . . is authorized to construct, maintain, and operate public park and recreational facilities and reservoir areas under the control of the Secretary of the Army and to permit the construction, maintenance and operation of such facilities."

More recently, laws as well as administrative actions have directed the Corps to increase its management role in the recreational aspect of water resource management. In one sense, recreation management has been dignified by statutory and administrative policy as an official function of the Corps. But even more important has been the activity of the American public. The simple existence of large and incessantly increasing numbers of recreating visitors puts strain and pressure on the natural resources of Corps projects, thus necessitating an active recreation-resources management program.

As American recreational demands began to expand in the sixties, Congress passed additional legislation. In 1962 an amendment to Section 4 of the Flood Control Act broadened the recreational authority of the Corps to include consideration for recreation at all types of water resource projects, not just reservoirs. Also that year the adoption of Senate Document No. 97 recognized long-term recreation development as having a status equivalent to other project purposes. Congress directed that recreation benefits be calculated and claimed at water resource projects.

The Federal Water Projects Recreation Act of 1965 required that consideration be given wherever possible to making outdoor recreational opportunities available. This act stressed the comprehensiveness of the responsibility for the recreation role. It did this by emphasizing that the Federal government should act in cooperation or partnership with other levels of government on these programs; financial costs were also to be shared.

The policies and goals of the National Environmental Policy Act of 1969 strongly emphasized that all practicable measures be used "... to fulfill the social, economic, and other requirements of present and future generations of Americans."

Traditionally, recreational opportunities have mostly received attention in terms of activities or facilities, but currently, under updated legislation, the value of recreation to the social well being of the American public is being emphasized.

Top-About two-thirds of Corps projects most used for recreation are located within a 50-mile radius of urban areas with a population of 50,000 or more. All projects indicated here offer varying degrees of recreation opportunities,

Self-propelled and trailer campers can cover lots of territory, making use of numerous recreation areas during the year.

Some sites, such as this one, are leased to concessionaires. Under the agreement, private firms maintain facilities at a level acceptable to the public and the Corps is responsible for maintaining the integrity of the watershed in which the site is located.

Some campers like to be close to the water, and one program objective is to keep these areas as near their natural state as possible.

Other legislation and the Corps' response to it is designed to insure that natural resources under its jurisdiction are managed in such a way as to maintain a quality environment. For example, the Corps as well as other Federal agencies must meet standards set by the Environmental Protection Agency for water quality at their projects by 1975. The Fish and Wildlife Coordination Act requires full consideration of fish and wildlife enhancement at water resource projects. Public Law 86-717 encourages reforestation to increase the value of areas for conservation, recreation, and other beneficial uses. Public Law 92-347 expands the use fee program for the Corps and other agencies that operate and maintain recreation areas.

The legislative and administrative series described above reveals a trend. First, recreation was recognized as being an acceptable project purpose; and then, encouraged as a project purpose because it was recognized as being of national importance because of its social values to the American public. Laws were next passed to protect the environment to insure that all future generations would have equal opportunities for the same types of experiences. The recent laws on use fees have been enacted for the purpose of offsetting some of the costs for operations, maintenance and improvements.

Left-More facilities are needed to expand the recreation opportunities for those who require special accommodations.

Even though the majority of people going to Corps recreation areas spend most of their time in land-oriented activities, fishing as a form of relaxation is an important attraction.

Maintenance, a major cost item, often calls for special equipment.

The use fee question generated considerable controversy, much of it over misunderstanding of what the charges would be for. Part of it was deep-felt resentment that facilities paid for in the first place with public tax money should be free to the public, especially to low income groups. One outcome of the controversy is that it caused us to begin to take a look at who is benefiting from what and who should pay for it.

One example is the findings from a study conducted by Oklahoma State University at a Corps recreation area. This was done under the direction of Dr. Daniel D. Badger, a resource economist, who had a graduate research assistant, Norman Wolff, survey recreationists, concessionaires and other businessmen in the vicinity of Lake Tenkiller Ferry.

They found that last year's attendance was over 3 million, and that the average size family group is 4.72 persons. Each family group had recreation equipment having an average value of at least $2,900. By occupation, the greatest number of users were craftsmen (26%), professional (20%), and managers and officials (18%). Their average income per household was $12,400. They found that about 94 percent of the household heads had at least a high school diploma and 17 percent at least one college degree.

The antithesis of urban reality, a low key case for the need for leisure.

About 80 percent of the users surveyed suggested the need for more campsites, that water and electricity be provided at campsites, also better restrooms with hot and cold showers, more picnic tables and more drinking water hydrants.

Dr. Badger reached these among other conclusions: "We found about 95 percent of the recreationists we surveyed would not object to paying a user fee for different activities if they knew the fees would be spent for needed improvement and for operation and maintenance. A significant point of the study is that most Tenkiller recreationists are well-educated, have above average incomes and professional jobs." From that he concluded that "people who are using the facilities, particularly the more sophisticated facilities, can afford to pay and should."

In essence the findings and conclusions from the Oklahoma survey are on common ground with the National Water Commission's analyses and recommendations. The commission recommends that "recreation administration and user fees should be charged wherever practicable. . . ." The commission report also emphasizes that Corps recreation facilities need upgrading, and specifically recommends that "recreation at Federal reservoirs should be elevated to a high priority program, not only in law and policy pronouncements, but also in

Left-All-weather parking lots, road systems and various accommodations compete for limited funds.

The handicapped coming to public recreation areas have every right to expect services as well as facilities tailored for their use.

coordinated planning, construction, operation, land acquisition, personnel and funding."

While legislation and the demands of people have given the Corps a management task of growing major proportion, it also has given our agency an opportunity to render a service—to show that the *Corps cares* about the wishes and recreation needs of American people. In fulfilling this, a major factor is the location of lakes built for flood control, hydropower, navigation and other uses. Roughly two-thirds of Corps lakes having recreation use are located within a 50-mile radius of metropolitan areas which boast a population of 50,000 or more. To meet this service and management challenge, we are emphasizing diversification in our recreation planning. We attempt to satisfy as many different types of users as possible. Also, where the project location and budget permit, the recreation facilities are open year-round. On top of that the Corps urges State, county, and municipal agencies to lease, construct and manage such specialized facilities as guest lodges, golf courses and tennis courts. Maximum participation by others is encouraged. The Corps sees no definable end to the continuing need for these specialized features, and no oversaturation of facilities developed by cooperating agencies is in sight.

Not to be overlooked is another type of cooperation with State and other Federal agencies interested in parks, forests, recreation, law enforcement and conservation. For instance, Corps lakes located on natural forest land are managed by the U.S. Forest Service in cooperation with the Corps. Wind barriers and reforestation projects are carried out in cooperation with the Forest Service or the Soil Conservation Service. At other places, State agencies enter into reforestation projects. Although the Corps has citation authority, law enforcement is in most cases an activity in which State and local police take the lead. These are only a few examples of cooperative programs which involve a rather broad cross-section of State, Federal and local agencies.

In practice the management chore of the Corps is in the form of twin tasks of recreation management and resource management. The key to successful management in this case is basically to develop new techniques and use patterns which reflect the wishes and needs of people. That may sound ambiguous, but in reality that's what it's all about; and to that end, our intent is to deter-

Above-This concessionaire caters to those who prefer counter to camping fare.

Right-Stores near recreation areas sell items not stocked by concessionaires.

Many boats launching ra

mine such wishes and needs and to maintain a quality level high enough to make Corps recreation areas the type of places that people will want to return to. In essence, we want a protected natural environment not only for public enjoyment, but to the degree necessary for sound functioning of each project's ecosystem.

In achieving this, there will sometimes be a conflict between management of recreation aspects and other project functions such as flood control, hydroelectric power generation, navigation, water supply, and fish and wildlife management.

Yet we want to see our facilities used for recreation to the maximum carrying capacity as long as this use is consistent with ecological, aesthetic and historical values. In other words, we hope to place equal emphasis on managing both the people-oriented aspects of projects and the natural resources in a manner that recreation features will be here not only for present but future generations. That calls for managing all resources, both developed and natural, as an integrated whole.

To do this we draw on the talents of Corps people who have a range of specialities. They include foresters, rangers, biologists, landscape architects, engineers and recreation planners. We try to apply good principles of forest management, fish and wildlife management and related disciplines to achieve overall ecological management of our program. The range of management practices is fairly well indicated by two totally diverse uses of resources. One is that of selecting areas to be preserved in or near their natural state. The other is that of providing developed recreation areas designated to meet specific visitor requests—for example, permitting off-road vehicles such as snowmobiles in some project areas.

The Corps has in the last 17 years been responding to a recreational growth over which it had no control. The Corps has thus found itself in a position of having to react quickly and unexpectedly to the demands of the public and the role of the Corps in the recreation field has shifted drastically over time.

Camping, for example, has become a recent national phenomenon. People are camping for different reasons. Some people attempt to use camping as a less expensive way to travel, stopping for a night's rest usually near an expressway or interchange. Destination camping, however, is the primary use that affects the Corps. The destination campers use a campground as a headquarters for sightseeing or participating in other recreational activities. They often set up their campground for several days and use it as a home base. They want to camp where a variety of activities are available and where the things to see and do are near the campsite.

Although these campers make some use of water, their other activities demonstrate that the needs and interests of the recreationist have grown beyond use of water alone.

Many boats come to the lakes on trailers, requiring launching ramps and also parking space for the trailers.

Preparation for the trip back home.

Their participation in camping is often a requisite to the participation in related activites. Therefore, a campsite on a water resources project having other activities available is more and more in demand.

One particular camping trend that has had an impact on management is the boom of recreational vehicles. Many of these are travel campers, the largest growing component in the camping industry. The estimated 5 million recreation vehicles currently on the road are joined by a half million more each year. One research institute predicts that the number of these vehicles on American highways will probably reach a level of 10 million by 1980, twice the current level. Those who have camper vehicles want comfort while they are getting away or escaping from the everyday work life. They are not interested in primitive camping, in doing without conveniences.

In summary, the magnitude of the importance of the land the Corps manages directly or leases is not going to diminish in use—the value of these lands will increase because the Nation's water-oriented resource base is limited. Public preference for water as a backdrop for participation in outdoor recreation activities can only be expected to increase. Even so, what people want to do in the outdoors, whether they want to ride off-road vehicles, camp, fish, boat or listen to outdoor concerts cannot be fully predicted. Therefore, we must concentrate now on maintaining our land and water resource base and in future years be in a position to meet outdoor recreational needs of the American public.

Throughout the summer, Corps personnel—those trained to perform a dual recreation and resource management role—have been developing improved recreation-resource management plans for project resources, forest management, fire protection, fish and wildlife management, and project safety. Researchers have studied the reactions of users to Corps facilities. The operation and maintenance costs of the recreation areas were studied. The effect that different types of recreational use has on the environment was also studied. Rangers patrolling Corps reservoirs used the newly acquired citation authority and also called upon local and State law enforcement officials to protect the public on project lands and waters.

The traditional as well as changing recreational interests of people were observed and noted, leading to the current status of a business that presents a continuing array of challenges to be met. And these are challenges that we cannot ignore, not as tides of visitors continue to converge on our recreational sites, seeking services and facilities and space. ■

LEVELS OF ASSESSMENT

by George W. Griebenow Chairman, Upper Mississippi River Basin Commission

What the year-old Upper Mississippi River Basin Commission achieves within the coming decade will have a far-reaching impact on a seven-State community. The Commission functions as a communication and coordination agent in a basinwide program of such scope that it may, in time, exceed $28 *billion.*

Of the total $28.5 billion capital costs projected for investment in water resources through the year 2020, approximately 46 percent is forecast to come from the Federal agencies involved. The rest will be provided by a combination of State, local and private investments—the mix depending on the precise package of program proposals actually undertaken. About 31 percent of the total capital costs can be expected to be spent on providing advanced wastewater treatment facilities for municipal and industrial needs. Significant percentages of the total expenditures could also go toward controlling streamflows for multiple uses such as water supply storage and navigation, the reduction of damages produced by floods and sedimentation, and improving drainage patterns.

These actions will call for approaches which will lead to the best possible decisions. To that end the commission already sees signs of success, but the first years of the commission's existence will set the pattern for its role in determining future uses of water and related resources in the basin.

The present thrust is concentration on establishing levels instead of types of planning. The commission takes

Opposite - In the Upper Mississippi Basin, multipurpose planning combines flood prevention with municipal water supply, recreation, habitats for fish and wildlife, and other water uses.

the broad, comprehensive study for the basin and determines which places need further probing as a prerequisite to any action. This generation of successive studies may appear to merely delay authorization of action programs that need attention *now,* and that may be true to some extent. But the basic premise is sound. Such exploration into the deeper layers at specific points in the general plan can reduce or eliminate the occurrence of wrong decisions.

As one of the newest river basin commissions, that is our aim. We intend to go about it by tackling the varied levels of planning with equal inputs by local, State and Federal interests.

Our commission was formed when President Nixon signed Executive Order 11659 on March 22, 1972. It joined together in a single institution 10 Federal agencies and five State agencies capable of making interstate decisions on water and related land resource programs.

Not long after, the newly established commission fell heir to the report completed by the Upper Mississippi River Basin Coordinating Committee previously created to guide the work of participating Federal agencies and State representatives. The report of the now abolished committee was published in June 1972.

Immediately, the commission had access to a comprehensive basin study that rapidly propelled it toward its next step—a more detailed study of water resource problems for designated priority areas within the basin.

The comprehensive basin study represents what is known as a framework, or "Level A," type of study. Since its publication, the commission has advanced to the next step with the 1972 publication of a preliminary plan of study for the Minneapolis-St. Paul metropolitan area's water resource problems. The first "Level B" type study to be announced, the seven county region covered by the Minneapolis-St. Paul metropolitan study area represents a narrowing down in scale and scope from the framework study. Examples of Level B studies under consideration by the commission are the Chicago Metropolitan area, the entire Rock River Basin in Illinois and Wisconsin, and the main stem of the Mississippi between Minneapolis-St. Paul and Cairo, Ill.

In each case, completion of the Level B study will be looked for in approximately two years after the study money is appropriated, followed as swiftly as possible by implementation or survey studies, which will represent a "Level C" look at more detailed problems. Upon completion of the future Level C studies residents of each area will pretty much know the specific actions to be undertaken before the end of this decade.

State, local and private interests must be involved from the beginning in order to achieve the joint plans or programs covering water and related land resources envisioned for the future at all levels of government.

Framework studies identify hydrologic, political, economic or other types of regions with problems complex enough to require a more detailed interagency or interdisciplinary scope of investigation. Or a framework study may lead directly to recommendations that specific implementation plans and programs be undertaken for areas that are not considered to need further study.

An interagency regional plan is really the preliminary or reconnaissance look at a selected area within the basin, intended to cover a mid-range forecast period 15 to 25 years ahead. A regional level study is usually called for when the problems, besides being interdisciplinary or interagency in scope, are so complex that this intermediate Level B planning step has to be inserted between the Level A and Level C studies.

Appropriate areas for regional studies may include tributary basins or sub-basins. Other studies may encompass political borders of one or more States within the commission boundaries, or some of their political subdivisions. Still others may work with identifiable economic regions, demographically significant areas or some other geographical makeup deemed most pertinent for the purpose of the study. The national guideline for river basin commissions promulgated by the U.S. Water Resources Council asks for completion of Level B studies as quickly as possible.

Our intent is to complete these regional studies within two years after getting funding approval, a budgetary step which the Minneapolis-St. Paul metropolitan area study now awaits. Once completed, however, this study should indicate exactly which programs or projects are feasible for undertaking by individual Federal, State or local agencies dealing with the Twin Cities. Individual agencies will then be directed to conduct Level C studies, each one to be completed approximately two years after funding. Finally, the action projects wrapped around use of a single resource by a given agency will present the specific design and maintenance details of direct concern to local users.

The obvious value of reducing the field of investigation progressively down to single agency or single resource size from a basinwide scale is to make individual action programs both manageable in size and in agreement with the UMRBC's basinwide goal. This is to provide the best use, or combination of uses, of water and related land resources to meet all foreseeable short- and long-term needs. Prerequisite to achieving this goal was accomplishment of a detailed inventory of the entire basin's resources that is included in the various appendices to the framework study.

Conducting this inventory took a large percentage of the time consumed and total volume of the report presented to the UMRBC, considering the scale of the basin.

The basin covers a watershed of 189,000 square miles,

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Millions of tons of cargo, such as the anhydrous ammonia in these specially designed barges, are transported through the basin's inland waterways.

or 121 million acres, of the north-central portion of the U.S. This is the area drained by the Mississippi River upstream of its confluence with the Ohio River at Cairo, Ill., except for the Missouri River. This drainage basin includes parts of Illinois, Indiana, Iowa, Minnesota, Missouri, South Dakota, Wisconsin and a very small portion of upper Michigan. Only the States of Illinois, Iowa, Minnesota, Missouri and Wisconsin are included in the commission.

Of the total basin area, almost three million acres, about 4,400 square miles, is covered by lakes, streams and the Mississippi River system—indicating the importance of various water uses to the basin's future welfare. For instance, about 28 percent of this water area is set aside for recreational uses. This percentage becomes meaningful when it is related to the physical size of the basin, which runs 700 miles from the mouth of the Ohio River almost to the Minnesota border with Canada. In width the basin is 500 miles across on a line from South Bend, Ind., to Big Stone Lake, S.D.

Central to the entire basin, of course, is the main stem of the Mississippi River, starting at Lake Itasca in central Minnesota. The main stem follows a winding southerly course, increasing in width below each junction with a major tributary. There are also three major metropolitan areas (Chicago, St. Louis and Minneapolis-St. Paul) contained in the basin.

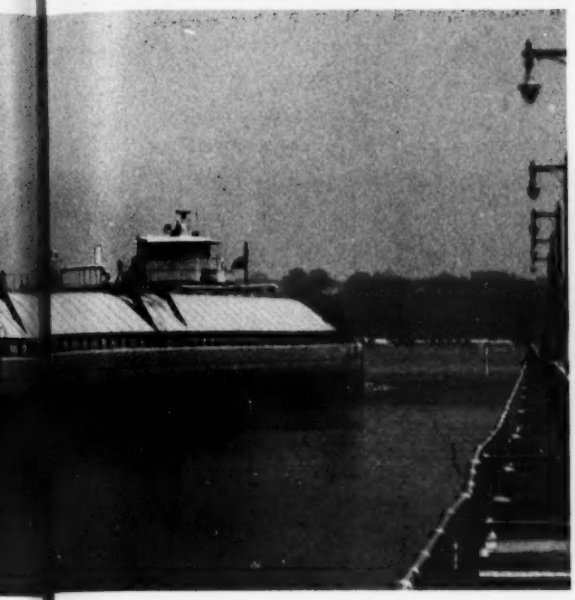
Basin population in 1960 was 19.3 million, projected to reach 48.2 million by the year 2020. It became obvious, therefore, that the three major metropolitan areas within the basin would continue to be the heaviest users of the basin's resources. Furthermore, each of the three areas is projected to increase its percentage of the total basin population within the framework study period.

The amount of land needed for urban areas in the basin is expected to exceed 10 million acres by 2020. The population growth and the shift to a more urban society will tend to concentrate utilization of water and related land uses even more in future years, creating special problems for urban areas. Thus, it was not surprising the priority system used to rank the 17 separate plan areas within the framework would highlight the Twin Cities and Chicago metropolitan areas among those most requiring immediate initiation of further study to determine specific future actions.

The upcoming Level B study of the Twin Cities metropolitan area, for instance, specifically draws its boundaries of investigation around the counties of Anoka, Carver, Dakota, Hennepin, Ramsey, Scott and Washington—a total of 2,820 square miles. The study's purpose is to investigate this seven county region's major problems and unsatisfied demands concerning the water supply by 1980, water quality problems on the Mississippi River, urban flood and sediment damage potential, preservation of the environment and, to a limited extent, the recreational opportunities available for regional development.

Under the rules of close cooperation adopted by the commission members, no study or action project can "go" without the concurrence of the governor of each affected State. In this case, the need for a study of the Twin Cities area has been confirmed by the State of Minnesota. Similar State level agencies have been named to commission membership by each of the other four governors whose States form part of the UMRBC.

Each of the 10 Federal agency members of the commission, through its regional representatives, will work with the State of Minnesota on this study, maintaining a truly regional rather than Federal perspective toward Twin Cities area problems. The same pattern will be followed for each regional study. Reaching beyond this form of successful Federal-State coordination achieved thus far, the commission is testing new ground by soliciting public involvement in the regional study.



The basin's population is becoming more urban each year, and three metropolitan areas already accommodate over half of the basin's people.

The commission expects to establish a special citizens committee to provide public awareness and participation. Committee membership would include area residents, conservationists and environmentalists.

Such a move is not unique. The commission's predecessor continually invited the League of Women Voters and other citizen representatives to Upper Mississippi River Coordinating Committee planning sessions. The commission is now engaged in an attempt to create the same spirit of Federal-State-local coordination at the next lower or regional level. Similar requests for local participation will accompany other Level B study areas as they are announced. Commission members deem this a wise method of securing a knowledgeable local public for any future action programs that are authorized in the coming years.

The Twin Cities study, first among the Level B's in the basin, also serves as a bellwether for successful translation of the objectives expressed in the Level A study into viable guideposts. In a sense, this first regional study appears as a microcosm of the framework study, emulating the latter's formulation of a comprehensive plan, including alternatives, that will satisfy multiple objectives dealing with water and related resources.

There are many such examples of parallel concern at the next lower level. Since wastewater management is so crucial to maintaining water quality, advanced treatment facilities rank high among the basin's overall needs. In line with the basin's overall needs, the Twin Cities regional study will consider wastewater management programs that will also not degrade the quality of Minnesota's priceless rivers and lakes.

Again at the framework level, there is a genuine concern for the 357 communities of 2,500 or more population within the basin with the potential problem of flooding. The Twin Cities regional study, addressing this concern, will investigate means of reducing flood losses and damages. Primarily, this effort will be directed toward examination of nonstructural measures such as flood plain zoning.

The basin contains nearly three million acres covered by water, of which a third is currently set aside for man's pleasure. Minnesota, famous as the self styled "Land of a Thousand Lakes," seeks controlled development of its recreation opportunities and protection of its existing fish and wildlife resources for the projected needs of the Twin Cities metropolitan area population.

In relation to the water supply problems expected to arise by 1980, a regional inventory will project what volume of water resources will be required to meet the Twin Cities demand for adequate municipal, industrial and agricultural water supplies within its seven county study area.

In addition, this Level B study will delve into the seven county area's economic stability and conservation needs. The latter include archaeological, historical and geological resources that should be preserved.

Not all 17 plan areas will necessarily require further study at the Level B regional or Level C implementation scope before actual projects are authorized.

The main stem of the Mississippi, for instance, already has several projects in existence. Current planning calls for considering year-round navigation of the river along its northern reaches, normally frozen over each winter. Flood control, commercial fishing and development of the Mississippi River National Recreation Area are other current concerns.

Therefore, probable program areas will involve many aspects of preservation, management and development. The challenge facing the commission is to find the best set of future actions among the many alternatives that exist for the people of the basin.

In parts of the basin, contour plowing and strip cropping reduce downstream problems from runoff, erosion, and sediment buildups.

In other parts of the basin, soil erosion has been a major source of sediment in the Mississippi.

Preservationist interests seek to protect such sites as the 13 national wildlife refuges within the basin, and add to the six national forests already identified; and they have been successful in obtaining Federally recognized wild river status for the St. Croix River. The two largest refuges, the Mark Twain and the Upper Mississippi River, extend 560 miles along the Mississippi River bottoms, providing 268,000 acres of wildlife habitat and cover. The endangered bald eagle winters on the Upper Mississippi River Refuge and the Upper Mississippi Valley is a major link in the Mississippi Flyway for migratory water fowl.

The framework study explains the basic necessity of protecting small mammals such as shrews, mice, bats, moles, chipmunks and ground squirrels, for their beneficial ecological role in acting as buffers between game birds and bird predators.

Aside from urban and environmental considerations, the continuing use of water as an irrigation resource will play a strong role in the future of the basin, since it makes up the agricultural heartland of the Nation.

The particular demands to be satisfied may not necessarily follow the developmental framework tailored to each of the plan areas by the framework study's task force. That situation creates no problem so long as the eventual programs undertaken turn out to be consistent with the overall objectives of the basin's population.

This developmental framework is only one possible mix of program components. Other planning policies would result in a different mix. For example, the States of Minnesota and Illinois have already expressed their own alternatives in terms of individual State planning principles.

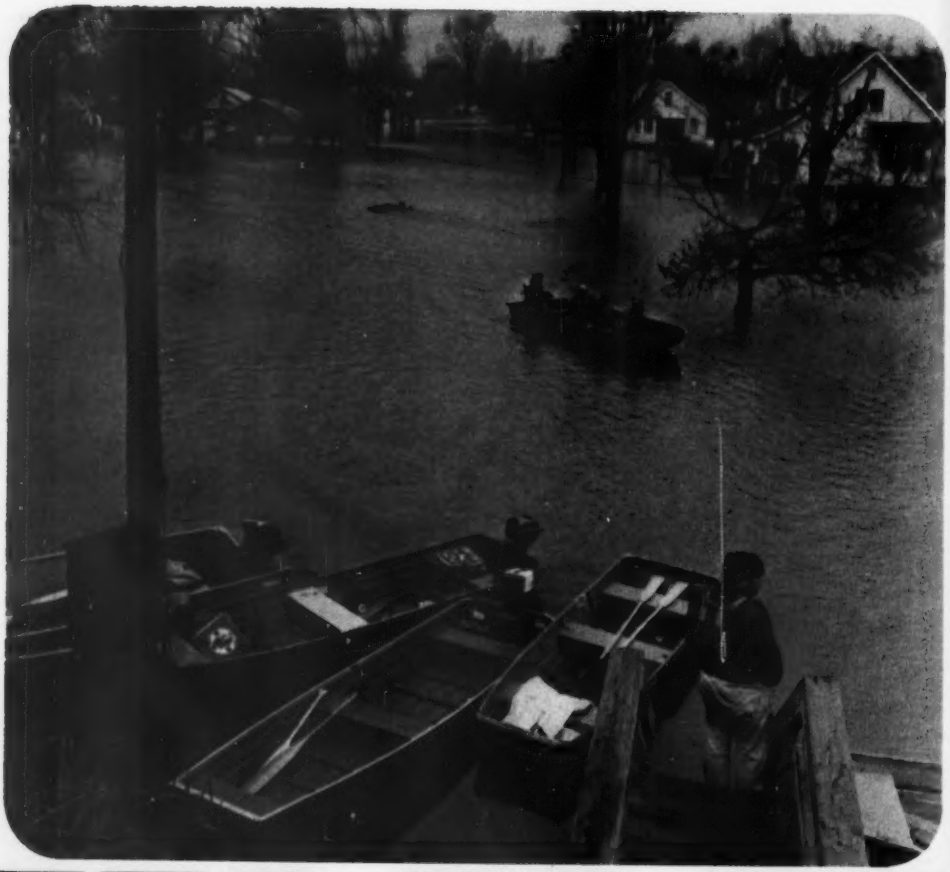
One aim at all levels of water use planning is the continued protection of the basin's waterfowl population.

The framework study itself represents just one of the four major responsibilities established for river basin commissions in the Water Resource Planning Act of 1965. Primarily, a river basin commission is charged with serving as principal coordinator of Federal, State, interstate and local water development plans. Its two other responsibilities, besides that of preparing a comprehensive plan, are to recommend priorities on future actions and conduct further studies where problems exist. The Upper Mississippi River Basin Commission convenes quarterly to discuss its progress toward meeting these four responsibilities.

Reiterating its primary function of coordination, the first step toward accepting that responsibility has been taken by the commission with completion of the comprehensive basin study. The task force for that study was composed of the major Federal agencies and State officials responsible for water resources, each of whose representatives had sufficient clout within their own organizations to get the job done. The next task is to gain acceptance of the commission's decisions within their respective agencies.

Perhaps the single most important advantage a river basin commission has over other planning institutions comes from its State membership. Not only is the commission a forum for expression of State views on Federal proposals, it is a mechanism to create multi-State leadership in water resource activities. The economics of coordinated action among the participating States are achieved by evaluating each State's needs and proposed actions in relation to those of the others.

The effort invested thus far will be followed by incorporation of local interests into the already established pattern of Federal-State coordination. All three levels of Federal-State-local government will be considered equal partners striving toward the wise future utilization of water and its related resources in the Upper Mississippi River Basin. ■



FLOOD OF '73

by
Herbert A. Kassner, Chief, Public Affairs Office
Lower Mississippi Valley Division/Mississippi River Commission
and
Roger P. Miller, Public Affairs Office, Seattle District,
on special assignment to LMVD.

Time tested flood control concepts were validated once again in *the flood of 1973.*

Between Hannibal, Mo., and Cairo, Ill., the Mississippi River surged to heights never before experienced since pioneers settled the area 200 years ago. Below Cairo, the river reached stages not recorded since 1937.

However, the 1973 high water was better contained than its predecessors, and the best comparison is the effect on human life. In 1927 more than 637,000 people were evacuated; in 1937 more than 800,000 people fled their homes; but in 1973, fewer than 40,000 persons had to seek shelter.

Conditions leading to the 1973 flood began last summer and early fall. Weeks and months of incessant rainfall filled flood control reservoirs along the tributary streams of the Mississippi. Fields became saturated, ponding areas filled, and the incessant rain could no longer be absorbed. Most of what fell became runoff.

Before long an ominous pattern began to appear in the hydrograph readings at Cairo, the head of the alluvial valley. By December, the river was assuming a typical pre-flood pattern somewhat ahead of the stage developments which preceded the great flood of 1927. As the river readings and general hydraulic conditions continued to follow the 1927 pattern, preparations were begun for a major high water, in accordance with the adopted plan for the control of floods in the Lower Mississippi Valley.

As coordinator of activities for the river as a whole, Major General Charles C. Noble, Division Engineer, Lower Mississippi Valley Division, and President, Mississippi River Commission, directed preparations and actual flood fighting. One of the first steps that General Noble took was to order a realistic, comprehensive flood fight exercise as early as possible in 1973. The regular biannual test, which was scheduled for later in 1973, was moved up to February. The great flood fighting machinery of the Lower Mississippi Valley Division was tuned in preparation for what was to come.

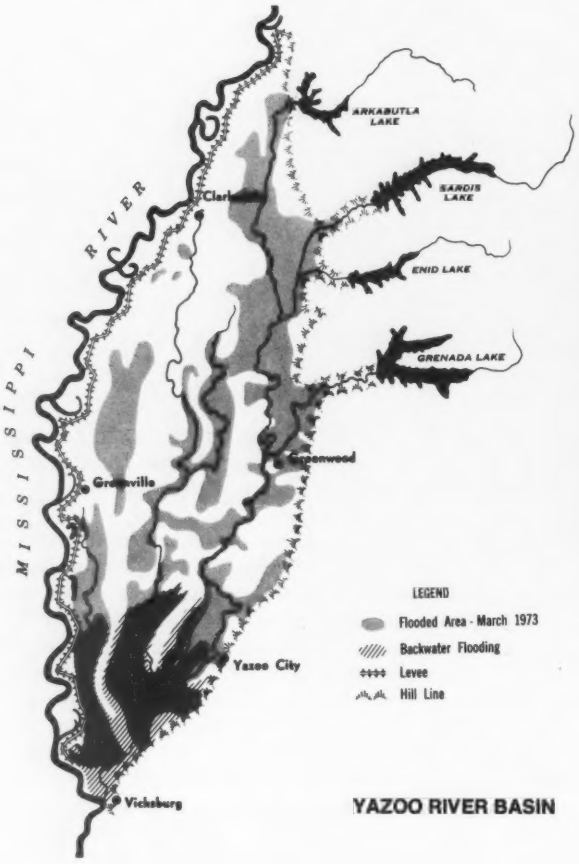
The vast geographical region of the Lower Mississippi Valley carries awesome responsibilities, for the Corps must, to the best of its abilities, assure the safety and well-being of those who live within the grasp of the mighty Mississippi River. To protect and preserve those who live in the rich Mississippi Valley, the Corps of Engineers has developed the Mississippi River and Tributaries Project (MR&T). This project is designed to control the *project flood,* which is the result of combining the most severe storms of record that have ever occurred in the valley and placing them in a pattern that would produce critical runoff conditions. The *project flood* would produce a combined maximum flow of about 3 million cubic feet per second in the Mississippi and Red Rivers.

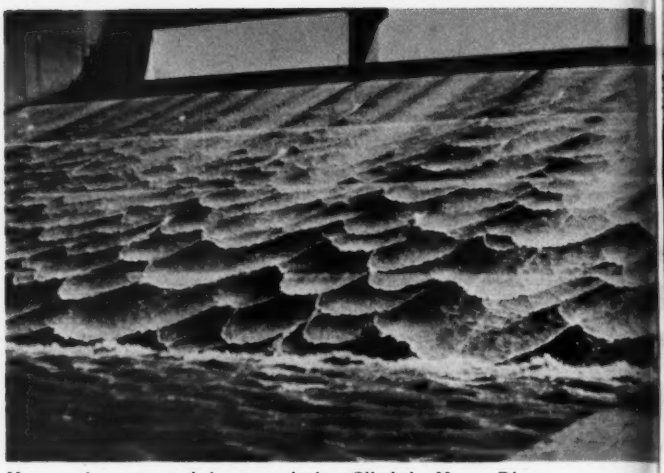
To control this great volume of water, the Corps of Engineers has designed an integrated system of those time-tested flood control features which, when completed, will protect a large part of the alluvial valley from the *project flood.* The four major elements of the plan are levees, floodways, channel improvements, and major tributary improvements.

The main stem levee system includes almost 2,200 miles of levees and floodwalls. An important adjunct of this work, particularly south of Baton Rouge, is foreshore protection to protect levees against wave wash.

The second element is the floodway system, four "relief valves" for diverting water from the main stem of the Mississippi to other channels. There are three floodways in Louisiana and one in Missouri.

Also in the plan is channel improvement to stabilize the alignment of the main stem and improve its flood-





Heavy rains saturated the ground, then filled the Yazoo River Basin reservoirs to spill level with the runoff as the flood swollen Mississippi's backwater spread over low lying areas of the basin.

carrying capacity. These improvements include cutoffs, bank revetments, dikes, and dredging. Articulated concrete revetments, made up of large mats of rectangular concrete sections, extend to the deepest part of the channel to protect the riverbank from currents, while dikes direct the flow into desired alignments.

The fourth element is major tributary basin drainage and flood control improvements, to control flows and to reduce flood damages.

Even though the MR&T project is only halfway finished, it played a major role in protecting important areas of the Mississippi Valley.

Early in the year, General Noble ordered the preparation of floodway control structures to ensure that all was in readiness for their use if required. Operation of gates was checked at Bonnet Carre, Morganza, and the overbank structure at Old River. Levees were checked and the entire MR&T mechanism was made ready for the expected onslaught.

An emergency operations center was set up at the division headquarters in Vicksburg, Miss., for the duration of the flood, as were centers in each of the four districts. The division operations center gathered and compiled data from each of the districts, so that an overall view of the river system was available to General Noble and his staff to enable them to make the proper decisions for maximum effectiveness.

Runoff from rainfall throughout the basin has to travel to the lower reaches of the river before discharging into the Gulf of Mexico. The division office had to decide how discharges from dams on tributary streams hundreds of miles away from each other should be released in order to regulate flows and prevent major surges from concentrating in the lower Mississippi simultaneously, causing much more severe flooding.

Spreading these tributary flow contributions greatly reduced the stages on the Mississippi. As an example, when main stem crests coming down the Arkansas River threatened to combine with a crest coming down from Cairo. General Noble arranged with the Southwestern Division to retard the flow on the Arkansas for a few days so that the crests would not coincide.

The history of the 1973 flood was one of crest after crest. Rain-fed waters draining into the lower Missouri and Illinois Rivers built the first Mississippi crest early in March, which hit hardest in the vicinity of Cairo, at the Mississippi's junction with the Ohio River.

The Mississippi went into flood stage at St. Louis on March 11 and in succeeding weeks, 39 non-Federal levees north of that city were breached or overtopped, inundating thousands of acres of farmland. When private levees failed at West Alton, Mo., at the junction of the Illinois River, 425 people were forced to evacuate. Many later returned to their homes only to be evacuated again in the face of new record crests.

A 360-foot footbridge was erected by troops from Fort Leonard Wood, Mo., to reestablish access to West Alton from Highway 67. Other military units were also called into action. The Coast Guard Reserve was activated to assist in emergency evacuation of those in imminent danger from the destructive waters.

South St. Louis areas along River des Peres were hard hit, and 300 buildings in historic St. Genevieve,

Closeup has Mississippi in background looking through a bay of the Bonnet Carre Spillway structure partially visible in picture below. Twin levees channel the diverted flood water toward Lake Pontchartrain and the Gulf.

Mo.—the oldest town west of the Mississippi River—were heavily damaged.

St. Louis itself, however, was protected by a floodwall and escaped damage from the greatest flood ever experienced on the middle Mississippi River.

Below Cairo, where the Ohio and middle Mississippi Rivers merge to create the lower Mississippi River, flooding was extensive. Tributary flooding occurred in Arkansas and Tennessee, forcing water into the already glutted Mississippi and pushing stages even higher.

During the 1973 flood, the only Federal levee failure occurred at Kaskaskia Island, in Illinois, which had not been raised to its authorized grade because of a lack of local interest. Last minute intensive efforts by the Corps and local interests, including student volunteers from Southern Illinois University, to save the levee continued until the record crest came downstream.

In Mississippi, the city of Greenwood was hit by a 10-inch rainstorm on March 15, causing extensive flooding of outlying subdivisions. This storm, with the additional rainfall that the area had experienced, filled the four reservoirs in the Yazoo River Basin, resulting in discharges over their emergency spillways. It will take months of carefully scheduled releases to lower levels in these reservoirs, and the Yazoo River will remain at near bankfull stages into 1974.

The mayor of Greenwood requested interim protection for this extended period. The Corps raised 28 miles of Federal levees by using flashboards, mud boxes, earthworks, and other expedients on an emergency basis. The citizens of Greenwood decided that the bare flashboards could be brightened up, so they held an art contest, with prizes for the best-decorated flashboards. Most of the entries reflected the determination to continue fighting, and the sense of humor that has been maintained throughout the flooding.

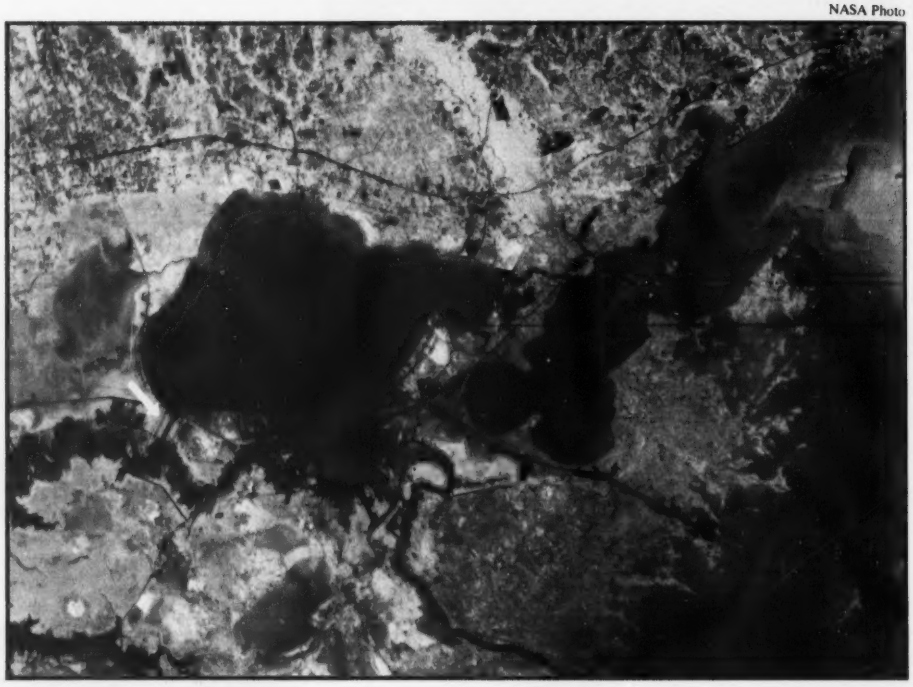
More than 2.3 million acres of the Yazoo Basin were flooded, either from Yazoo River headwater or by the Mississippi River backwater. An area of over 900 square miles north of Vicksburg, Miss., was inundated from the backwater effect.

Backwater flooding was also experienced in the unprotected portions of Catahoula Parish of Louisiana in what is designated the Red River backwater area. This water eventually overtopped a Louisiana Department of Public Works levee near Jonesville, La., despite a valiant flood fight effort to save it by the Tensas Levee Board with State and Federal assistance. When wind-whipped wave action undermined efforts to raise the crown of the levee above the water level, an emergency ring levee was built by the levee board to protect the hospital, airport, business firms, and nearby homes located outside the Federally-constructed levee around the city.

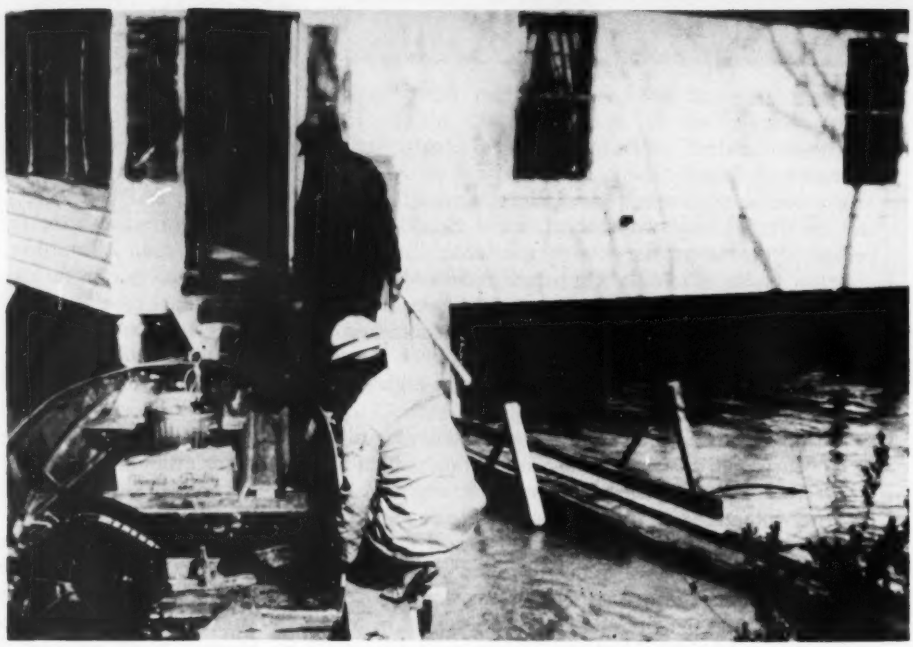
Low sections of levees in the Atchafalaya Basin and the floodwalls in the Morgan City-Berwick, La., area were raised on an emergency basis. Because the MR&T project is only half-finished, incompleted protection works had to be raised immediately in order to protect against the possibility of a project flood.

Although areas around Morgan City outside of the protected areas were flooded by a torrential rain and high tides, the major part of the city was protected. Elements of the Louisiana National Guard, under com-

NASA Photo



Satellite imagery of Bonnet Carre Spillway (arrow) illustrates diversion of Mississippi River flood water into Lake Pontchartrain. Light-colored swirls indicate fresh water flows flushing out darker salt water wedge and depositing tons of slit in the lake. White lines upper right are the result of data gaps in electronic scanning process.



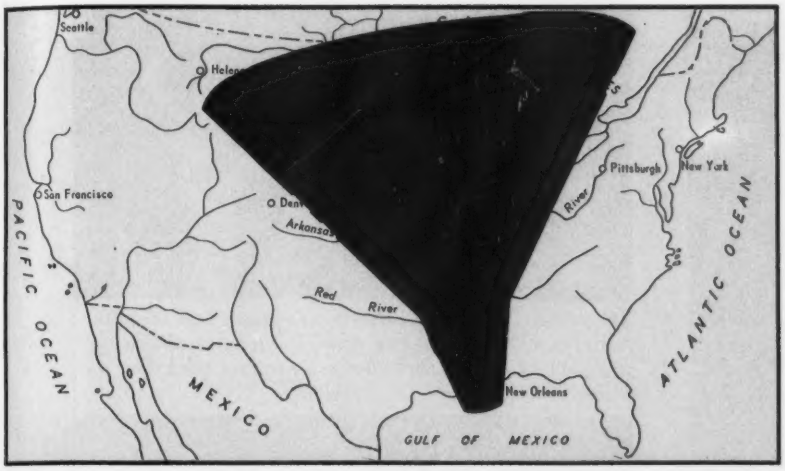
Oft repeated scenes such as this became commonplace as flood waters forced almost 40,000 to evacuate the flood plain.

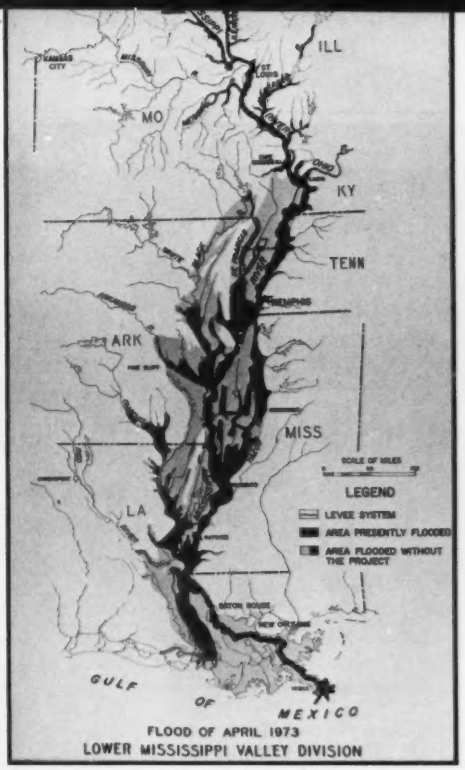
mand of Major General O. J. Daigle, spent several weeks in the Morgan City area, evacuating people, raising local levees, sandbagging, and accomplishing other vital missions.

To provide additional skilled manpower and heavy equipment, the Fifth U.S. Army sent two reinforced companies of the 62nd Engineer Battalion from Fort Hood, Tex. These soldiers worked on the floodwalls and levees to shore up the protection for that area.

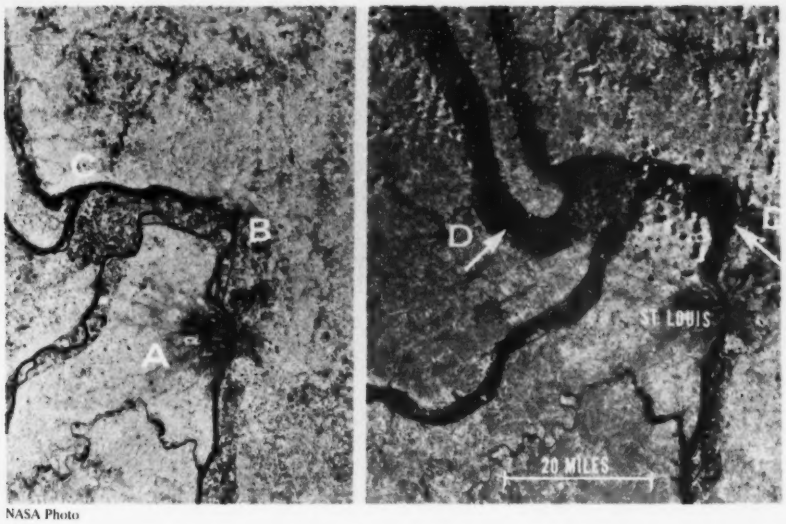
In some areas a wave-wash effect was created by winds that caused portions of banks to slough off or crumble into the water. At still other points eddying currents scoured out supporting ground, causing banks to slough off. This type of action led to the construction of emergency setback levees at Montz, Nairn, and near Plaquemines, La. The setback levee construction at Montz required the relocation of 44 families.

Scouring action at the Old River Low Sill Structure, which controls the flow of the Mississippi's water into Louisiana's Atchafalaya River, caused the collapse of a wing wall and created a 65-foot deep scour hole, threatening the main structure. Emergency measures were taken to stop the eddying currents and to fill the hole, and water was diverted through other structures to relieve pressure on the Old River Structure. The Overbank Structure at Old River was opened on April 15, and





Above-The "project flood" would have inundated additional acres had the Mississippi River and Tributaries Project not been built.



Above left-This superimposed rain funnel dramatizes the vastness of the Mississippi watershed that drains 41 percent of the U.S. mainland—catching runoff as far away as Montana to the west and New York to the east.

Left-Satellite imagery indicates areas under water by the spring of 1973 (D) compared to still normal conditions the preceding fall at the confluence of the Illinois (C) and Missouri (B) Rivers with the Mississippi above St. Louis (A).

NASA Photo

two days later the Morganza Floodway was partially opened for the first time.

Morganza was closed later that day to allow more time for wildlife to find sanctuary and to give local interests time to repair and close a jammed gate in the Pointe Coupee levee drainage structure. Subsequently, the structure was partially reopened.

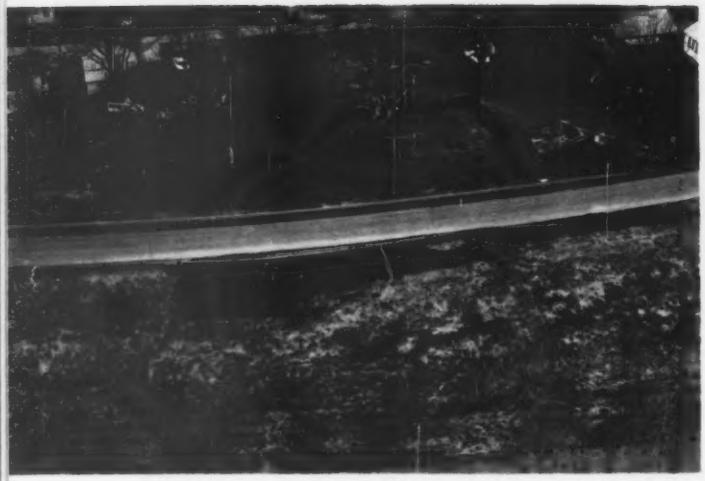
In dealing with the flood, the division headquarters often had to contend with rapidly changing conditions. Predictions that were made several days in advance, based on National Weather Service and hydraulic data, had to be revised. More rain than was anticipated fell, forcing the Corps to revise predictions upward. Adding to the difficulty of making accurate predictions was a phenomenon called the rating curve loop, which results from a falling river requiring a higher stage to pass a given volume of water than a rising river. Consequently, each successive crest forces higher the stage at which the river can pass the given volume of water, and the lower Mississippi experienced three crests in the 1973 flood.

As an example, in Vicksburg, during April, the river went through succeeding crests, and for a flow of 1,750,000 cubic feet per second it produced stages ranging from 48 feet to 50.4 feet. This 2-foot increase in stage for a given volume of water resulted in much additional flooding in the Yazoo backwater area.

The flood of 1973 has broken several long-standing records for duration. In the St. Louis area the river remained at flood stage for 77 days, breaking the old 1844 record of continuous flooding for 58 consecutive days. The St. Louis crest of 43.2 feet reached on April 28 was the highest in the 200 years of recorded history. In the lower portion of the river, the 1927 flood holds the record of 166 consecutive days above flood stage.

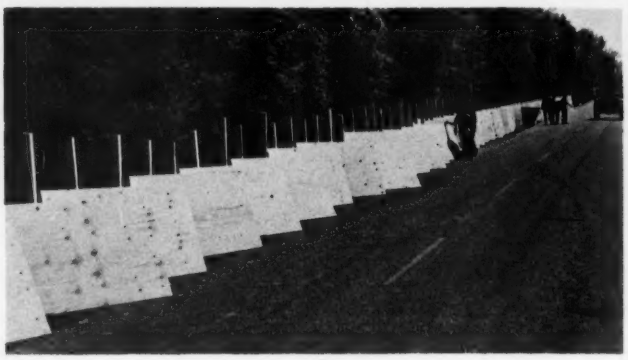
Compared with the havoc wreaked by the 1927 disaster, the main flow of the flood of 1973 was nursed harmlessly into the Gulf. Unprotected areas along tributaries did suffer considerable damage, however. Over 12.6 million acres in seven States, largely in unprotected backwater areas, were inundated for a considerable period, forcing over 39,000 people from their homes. The estimate of damages for the 1973 flood has climbed to over $420 million.

Without the MR&T project, more than 10 million highly-developed additional acres would have been flooded, including just about all the major population and industrial centers in the lower valley. Losses would



Dirt slide weakens this road-topped levee at New Madrid, Mo., as Mississippi River continued its rise.

Members of the 62d Engineers from Ft. Hood, Tex., dig post holes preparatory to installing flashboard flood protection at Morgan City, La., similar to that being readied along this highway (below).



have easily exceeded $7.7 billion, dwarfing the 1927 disaster by comparison.

Hardest hit was the State of Mississippi, where approximately a quarter of the estimated damages occurred. Corps of Engineers economists estimated commodity losses throughout the Lower Mississippi Valley at approximately 750,000 bales of cotton, 40,000,000 bushels of soybeans, 100,000,000 bushels of wheat, 100,000 tons of sugar cane, and 25,000,000 pounds of rice.

Although early flood warnings allowed farmers to remove thousands of head of livestock out of the reach of the rising waters, early shipment to market for quick sale and loss of pasturage cost from 50 to 100 million pounds of meat.

The 1973 flood also had a serious effect on navigation. The strong, difficult currents forced many operators to reduce or stop operations. At times traffic was as much as 50-80 percent below normal. During parts of April and May, when the locks on the middle Mississippi had been flooded and wave wash would have endangered levees, it was necessary to close the river to traffic north of Cairo. Operators tied barges in slackwater areas all along the river as they waited for safer conditions.

This has been a tremendous flood—one of the great ones in the Mississippi River's history. The maximum flow of the water in the river was about 15 million gallons per second, which is enough to provide the city of New Orleans with its daily water supply in less than 10 seconds of each day's flow.

Combatting the flood required efforts of equal magnitude. In the Corps of Engineers alone, almost 2,000 men and women of the Lower Mississippi Valley Division have been working full time on the flood, sometimes almost around the clock. They have been augmented by more than 200 employees from other Corps divisions and by more than 400 active Army troops. The Corps has strengthened or raised more than 500 miles of Federal levees along the Mississippi and its tributaries. It has also issued more than 10 million sandbags, loaned hundreds of pumps to local communities, and assisted local flood fighting efforts throughout our seven-State area.

In addition, by the time the fight is over, the four districts in the division will have granted more than 400 contracts for work to implement that of Government agencies. There has been a great financial cost in this flood fight. The division has estimated that the direct flood fight expenses will be about $50 million, and repairs to Federal projects after the flood will require another 50 to 60 million dollars.

This flood fight has been a team effort by many Federal, State and local agencies. Local governments, police agencies, the National Guard, volunteer organizations, and thousands of volunteer workers have proven once again that people can work together in times of adversity.

The Lower Mississippi Valley Division office, acting as a coordinating center, ordered one of the largest and most effective flood fights in the history of the United States. Its MR&T project has more than met every demand in those areas where the project has been completed. Functioning as designed, the completed features prevented a catastrophe.

Much work in the MR&T project is yet to be completed, but the careful planning and quiet preparation that has been going on for years has paid off well in this tumultuous flood of 1973. ■

BOSTON TO BROWNSVILLE

by Seymour Reitman

The Atlantic and Gulf Intracoastal Waterways add up to 3,000 miles of interrupted navigational channels stretching between Boston Harbor and Brownsville, Texas, giving users the option of bypassing some of the most treacherous offshore hazards and time consuming routes.

Indian canoes were probably the first to navigate shallow canals dug through narrow necks of land in the Northeast during the Colonial days of America. Today, Corps-maintained channels 12 feet deep and 125 feet wide are none too large for the modern inland towboat and its barges.

Over 300 years passed between the earliest local improvement, a canal dug in 1643 from Ipswich Bay to Gloucester Bay, Mass., and completion of the main channel between Corpus Christi and Brownsville, Tex., on June 18, 1949.

Its growth has kept pace with the progress of the United States. Its values have changed with those of America. Both can be traced by the overall waterway, which varies from reach to reach in type of use and local attitude toward this placid, manmade boon to inland navigation.

Overall, the Atlantic Intracoastal Waterway is known for its preponderance of recreational boaters and yachtsmen, who ply it on their seasonal migrations from Maine to Florida. Commercial barge traffic predominates along the Gulf sector, between western Florida and the Mexican border.

A silent partner to America's changes, this broken chain of federally maintained coastal channels has been recognized at various times and locales as a protected waterway, endangered species sanctuary or ominous threat to adjacent ecological values.

Historically, many private or State owned waterways making up today's Atlantic segment were forced upon the Federal Government in piecemeal fashion as the expense of maintenance became too burdensome for the original owners. The Gulf segment, in contrast, was a relatively unsettled area which developed with the growth of the waterway under the continual urgings of the Gulf Intracoastal Canal Association, representing commercial and industrial interests throughout the Gulf Coast States.

These respective images of the Atlantic and Gulf Intracoastal Waterways are not truly pure. Intermixed with plush yachts commuting up and down the Atlantic reaches are seagoing freighters with several-hundred-foot-long keels, or speeding powerboats churning the water into bank eroding wakes, or shoreline fishermen lazily casting into limpid canal water.

Along with the water commerce engendered by offshore oil rigs in the Gulf, the latter waterway's image includes Mississippi River barges, bilingual bayou residents paddling piroques or "piro boats" between farm and marketplace, and Cajun tugboat pilots speaking French over their marine radios.

Differing images, however, sometimes confuse the casual observer and block out recognition of why the Intracoastal Waterway came into existence. In an earlier day the lack of adequate overland transportation kept many a coastal community isolated from nearby communities when heavy seas prevented travel via open waters of the Atlantic Ocean or Gulf of Mexico. Going "outside" involved the danger of shipwreck by being driven into an unseen hazard, such as the treacherous Diamond Shoals off the Outer Banks of the Carolinas. Thus, small reaches were initially dug as privately owned toll canals used according to company rules.

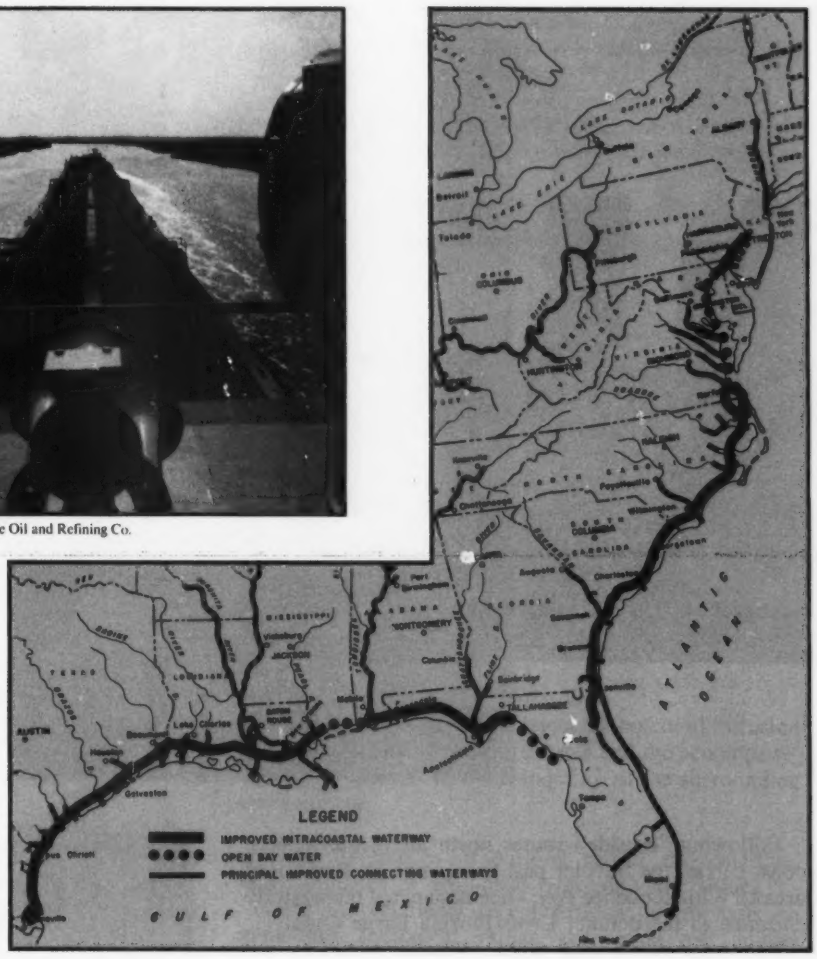
As widths and drafts increased, however, the attendant expense of ever widening and deepening these canals overwhelmed the financial capabilities of the private and State owners. While the steady growth in vessel size made the locks in these canals obsolete, dredging and other maintenance costs continued to rise, and local interests gave way to regional viewpoints as the still young country's commerce expanded. The weighty combination squeezed private and State waterway owners, encouraging each one to approach Congress for permission to turn over maintenance responsibility to the Federal Government. This unintentional, piecemeal acceptance of privately owned canals eventually coincided with later projects, Federally inspired, deliberately linking two or more intracoastal segments into a continuous navigation channel.

The precedent for Federal acceptance of responsibility for a future intracoastal waterway was set by Congress in 1824. In that year Congress authorized the Corps of Engineers to conduct a snagging operation on one of our overgrown inland rivers to improve its navigability. An 1828 authorization followed for the navigational purpose of enlarging the existing waterway between the St. Johns River in Florida and the Cumberland Sound in Georgia. Successive congressional authorizations through the years firmly established a pattern of inland navigation projects undertaken by the Corps.

It wasn't until 1873, however, that a project was adopted that could actually be considered the beginning of a comprehensive navigation plan for a region that is now part of the Intracoastal Waterway. This project proposed to put a 7-foot deep, 60-foot wide channel inside the Southern Branch of the Elizabeth River at Norfolk, Va., to the northern entrance of the Albemarle and Chesapeake Canal. Since then, today's main channel south of Norfolk has been expanded into a uniform 12-foot deep waterway extending into northern Florida. At that point, the absence of the halted Cross-Florida Barge Canal requires traffic to "go outside" into the open

The petroleum industry is the largest commercial user of the Gulf Intracoastal Waterway.

Photo — Leo Touchet, Humble Oil and Refining Co.



Even with 3,000 miles in existence between Boston and Brownsville, many reaches of the placid Intracoastal Waterway are separated by wide stretches of rough "outside" waters.

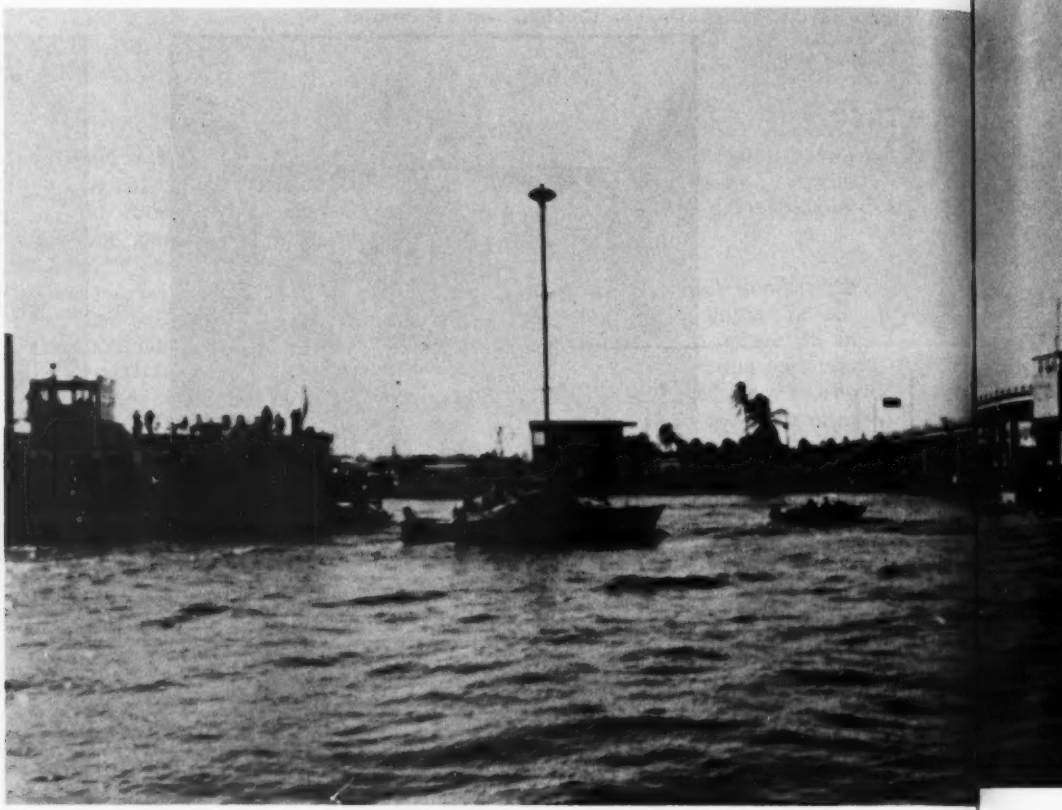
waters of the Atlantic. Widths along the southern coasts vary from 90 feet, where it was necessary to make land cuts, to as much as 300 feet in areas of natural open water such as the numerous sounds that abound inside the Outer Banks off the Carolinas.

It was probably this organized approach toward excavating the southern reaches that prompts many a Gulf Coast sailor to believe the Atlantic Intracoastal Waterway starts at Norfolk. But those who sail through the more northerly Chesapeake and Delaware, or C&D, Canal linking the head of Chesapeake Bay with upper Delaware Bay realize that notion is wrong. They consider the beginning of the Atlantic segment to be farther up the Delaware River, at Trenton, N. J. The truth lies even farther north.

Water traffic coming south from Maine and New Hampshire first becomes recognizable as intracoastal where its route cuts across Cape Ann on the northern coast of Massachusetts. Then it enters Massachusetts Bay off Boston Harbor, slices across the narrow neck of Cape Cod, sails between Long Island and the Connecticut coastline down past the New York City skyline into New York Harbor, and then enters the approximately 111-mile long New Jersey Intracoastal Waterway. Continuing inside the coastal barrier islands of New Jersey, this traffic crosses the Cape May Canal into Delaware Bay, where it merges into water traffic out of Trenton and Philadelphia bound south toward the C&D Canal.

South of Norfolk the waterway splits into the commercially used Albemarle and Chesapeake Canal to the east and the more scenic, but shallower route through the Dismal Swamp farther inland. Cutting across the mouths of numerous sounds, the waterway finally reaches the St. Johns River in Florida and follows it inland past the city of Jacksonville.

Nonlocal traffic, however, continues southward to the Ft. Lauderdale and Miami areas, terminus for most of the pleasure craft, or heads westward via the "Great Circle" route inside the Florida Keys. (Shallow draft barges and power boats cut across farther north via the St. Lucie Canal leading to Lake Okeechobee on the way to the west coast of Florida.)



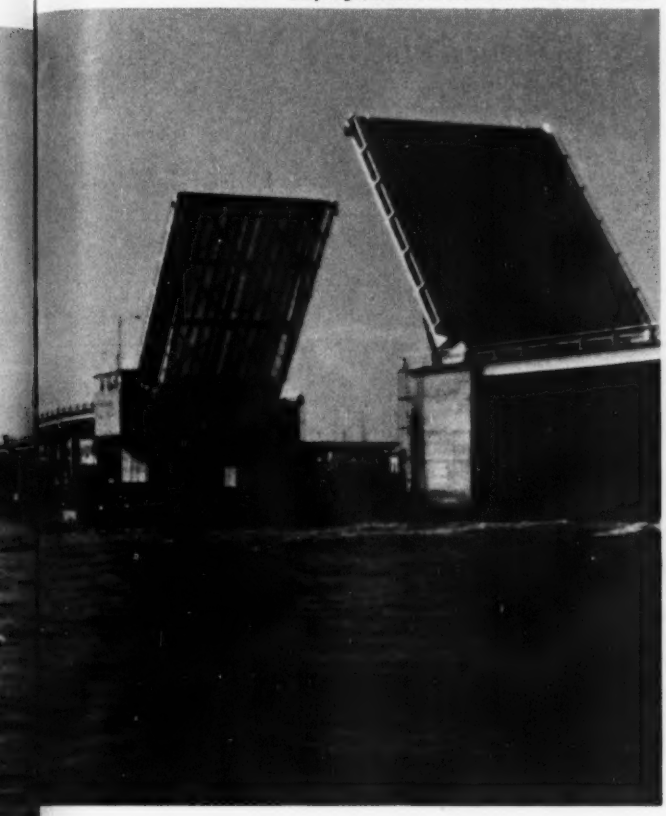
Following "outside" routes north along the western coast carries the traveler past the Tampa-St. Petersburg area to Withlacoochee Bay, once designated the westerly entrance to the defunct Cross-Florida Barge Canal.

The intervening 120 miles of open water to the proposed eastern terminus of the Gulf sector at St. Marks, Fla., on Apalachee Bay is still referred to as the "missing link" by intracoastal advocates. However, another 42-mile section leading westwood to Carrabelle from St. Marks has never been dredged for fear of disturbing the unique ecological area of Alligator Harbor on St. James Island. The latter sits landward of St. George Sound, where the largest stretch of unbroken *Gulf* Intracoastal Waterway channels begins, as traffic from the "outside" route slips inside, turning westward toward Apalachicola Bay.

Unlike the piecemeal growth of the older Atlantic section, the sustaining force behind the birth and expansion of the Gulf section has been the Gulf Intracoastal Canal Association. Although some private canals around the already thriving seaport of New Orleans were incorporated, the Gulf section, by and large, was cut through a strip of coastal wilderness. Outside of New Orleans, only fishing villages fronted the Gulf. Houston was still an inland city and the island port of Galveston was reviving from the devastating hurricane-driven waters that inundated it five years before the association's birth in 1905.

Manmade islands built of spoils from an earlier day have been altered by the hands of time and nature, becoming bird sanctuaries that afford protection for many rare species.

Photo — Larry Singer, Greater Fort Lauderdale Chamber of Commerce.



Florida's highway system has learned to accept seasonal migrations of pleasure craft by alternating the right-of-way between land and water traffic. The 17th Street Causeway spanning the Atlantic Intracoastal Waterway at Fort Lauderdale opens and closes at 15-minute intervals.

Bridge tenders at some locations use TV monitors to pick up approaching craft, and they maintain a log of each vessel's type and direction of passage.

On August 8 that year a convention was called at Victoria, Tex., based on the idea of digging a 700-mile long canal through the Louisiana and Texas coast as a means of providing "cheap fuel and transportation" for the region.

Initial segments were only authorized to be dug 5 feet deep and 40 feet wide at the bottom. By the time of the River and Harbor Acts of 1925 and 1927 congressional authorizations were supporting a true intracoastal canal 9 feet deep and 100 feet wide from the Mississippi to Corpus Christi, recognizing the concept of "through" transportation.

Later authorizations extended the construction eastward from New Orleans and, in response to increasing vessel size, permitted widening of the bottom to 125 feet The bottom width is now 150 feet west of Mobile Bay, and current authorizations permit an average depth of 12 feet with even wider dimensions in some areas—such as the 36 by 500-foot ship channel for the Mississippi River-Gulf Outlet at New Orleans. Here the waterway uses part of the State-owned Harvey Canal where traffic must pass from the Mississippi through a ship lock which has become a notorious source of transit delays for the towing industry. Industry spokesmen claim modern barge tows require locks at least 110 feet wide and 1,200 feet long to match today's inland marine equipment. The Industrial Canal Lock is only 75 feet wide and limits barge lengths to tows of 1,180 feet. Public hearings by the New Orleans District Engineer indicate that nearby St. Bernard Parish residents resent the potential intrusion of new or expanded lock structures and the accompanying traffic growth on the tranquility of the surrounding environment.

Such differences in outlook reflect the emerging dominance of ecological over economic values.

Until the relatively recent nationwide emphasis on preserving ecological values, excavation and annual maintenance dredgings of the waterway were generally considered more an economic benefit than a slur on the environment. Years of digging and dredging left many spoils areas, but nature's inexorable urge to recycle itself plays a never ending part in more settled reaches.

A case in point is the extensive construction of the waterway through the coastal areas of the Carolinas and Georgia. The enormity of this time consuming project fully occupied the working careers of many a father-son combination among Corps employees engaged in excavating land cuts and dredging existing bodies of water to a uniform 12-foot deep, 125-foot wide bottom channel. Besides adding new sections to the Atlantic Waterway, these work crews left behind manmade islands of dredge spoils that the passage of time has stabilized with vegetative covers attracting many species of birds to these desirable sanctuaries. Today, a generation unaware of these islands' manmade origins insists they be protected by State law from man's incursions.

More recent spoils provide other benefits. Current owners of Old South plantations that once used the waterway as their only means of travel now ask the Charleston Engineer District to permit Corps contractors to spread dredge spoils on their nearby crop-

Rice fields, swamps, lush wilderness and industrial plants are typical neighbors as the Gulf Intracoastal Waterway wends through southern Louisiana.

Right- This barge tow utilizes one of the many land cuts that link natural bodies of water into a continuous intracoastal channel.

lands. The soil enriching nutrients contained in the spoil increase yields considerably.

In the South Texas coastal region of the Gulf sector there has been justifiable consternation over destruction of rare bird feeding areas by dumping of spoils onto a unique area of coastal marshlands. Meanwhile, the Great White Heron (whooping crane) rockery at Aransas National Wildlife Refuge seems to have survived the waterway's invasion of the Laguna Madre behind the Texas coastal islands. This rookery has not only subsisted, but actually become a mutual tourist point for both man and bird as the latter return the curious stares of the local tour boat's passengers. It is now common comment along the Gulf that "the whooping cranes are worth a million dollars to the State of Texas."

When a recent contract was let to dredge a side channel to Liberty, Tex., the Corps insisted the contractor's work could not start until some bird eggs in that area were hatched. The contractor dutifully waited.

Such environmental concerns take on a different characteristic at other places along the canal. The recent protest against the canal's planned extension through the Delaware-Maryland-Virginia (Delmarva) coastline is an example. This was prompted by the spector of danger to protected wilderness areas: such as Assateague Island National Seashore and the wildlife habitats dotting the offshore barrier islands stringing down to the Virginia Capes. Tugboat operators and recreational power boaters, however, were pleased with the proposal to dredge 145 miles of channel through the Delmarva Peninsula's coastal wetlands. Tourist interests in the nearby resort area of Ocean City, Md., enjoy the prospect of a 6-foot deep, 100-foot wide channel, while conservationists deplore the concomitant dredging, pollution and commercialization.

A partially excavated canal at the south end of the Atlantic section was halted by Presidential fiat to protect the unique ecology of northern Florida's St. Johns River. Those who favored the project conceived of this Cross-Florida Barge Canal as the penultimate link uniting the Atlantic Intracoastal Waterway with the Gulf Intracoastal Waterway.

While the waterway has had its share of complex problems of concern to the Nation as a whole, where jurisdiction is divided among Federal and State agencies matters become even more complicated.

By way of illustration, most of the bridge crossings belong to the individual State highway departments along the waterway route. Thus, when a State highway department dumped several tons of rock around the weakened footings of a State highway bridge, the action induced waterway turbulence that can not be eliminated without extensive Federal-State negotiations.

Local circumstances determine the degree of Federal-State division of responsibility. In North Carolina and Florida, where older, low-level draw and swing type bridges persist, bridge tenders are Corps employees. Where modern concrete high-rise, fixed-span bridges exist, the State highway department accepts responsibility. The reasoning is based on simple economics. Fixed-span concrete bridges require no tenders and less maintenance.

The gradual passing of bridge tenders from the intracoastal scene lessens the Corps supply of human recorders for waterborne traffic statistics. Each bridge or lock with a resident tender maintains a log of each vessel's type and direction of passage. Remaining today are those at Great Bridge and Deep Creek Locks, who log traffic passing through the Dismal Swamp or Albemarle and Chesapeake Canals of North Carolina, respectively. Remaining bridge tenders still log recreational boaters passing south and north under Palm Valley Bridge near Jacksonville, Fla.

The commercial traffic totals on the Atlantic section tend to be smaller than those of the Gulf due to the predominance of pleasure craft on the Atlantic section. Each year fall migrations of handsomely appointed yachts drastically outnumber commercial craft. The yachts head southward for Florida's coastal towns, converting them into marina communities whose establishments are predominantly entered from dockside during the winterlong vacation stay. In the spring the yacht fleet migrates northward to summer playgrounds off New England.

Photo—Lee Truchet, Humble Oil and Refining Co.

Autos and vessels compete in the larger coastal communities, such as at the 17th Street Causeway spanning the waterway between downtown Fort Lauderdale and the beach. A city erected roadside sign on the causeway informs approaching motorists the causeway opens at 15-minute intervals, alternately giving the right-of-way to auto and boat commuters and providing a 15-minute countdown mechanism for convenience.

Many yachts flying "owner absent" burgees are raced to their winter sun and fun marinas by hired crews whose haste for their paychecks sometimes builds monstrous wakes that erode private riparian property. Where a State has arranged for the Corps to police the waterway, this becomes an additional burden on the district office personnel.

Without movable bridges or locks a district can only estimate non-commercial vessel passages. Above Norfolk, one of the remaining vestiges is the railroad "lift" bridge about midway along the 16-mile C&D Canal. Despite appearances, the removal of the other four movable bridges on the C&D was not part of modernization planning as explained by resident engineer Barney Schwartz, who pointed to a yellowed news photo showing one of the old bridges draped over the bow of an errant freighter. Hard to believe, but all four of the old timers met untimely ends in the same manner—and the inoperative railroad bridge itself is undergoing repairs for the same reason.

Traffic through the C&D typifies the intermix of seagoing freighters and tankers with smaller draft fishing boats and yachts found along the northern reaches of the Atlantic section. Bypassing the long outside route around the Virginia Capes, the C&D saves 290 nautical miles, for instance, between Philadelphia and Baltimore. That's equal to "roughly one day's sailing time" declares Howard Cosgrove, who operates the canal's TV monitors and communicates with all the regular pilots on a first name basis via two-way radio.

Diagonally across the canal from the Corps office is a "pilot shack" where Maryland and Delaware licensed pilots swap vessels as they cross the State line in either direction. Pleasure craft stop at the same point for one of the well known seafood restaurants that cater to the waterway's leisure traffic crowd. (Unique among the patrons frequenting this particular establishment is the business group that lands its helicopter in the parking lot for lunch.) Similar dockside eating establishments situate themselves next to the marinas and abound in competitive numbers where berthing and maintenance facilities for pleasure boaters tend to cluster along the Atlantic section.

While the waterway bustles with barge and boat traffic, whooping cranes take refuge in the marsh alongside it.

Photo—Leo Touchet, Humble Oil and Refining Co.

There are still other amenities for the leisure boat owner. The pumphouse preserved at Chesapeake City, Md., contains the giant "walking beam" steam engine once used to power locks on the C&D before its conversion to a sea-level ship canal. Several prehistoric fossil sites have been uncovered along the C&D. Further south, the waterway runs through the tea-colored waters of the Great Dismal Swamp fed by picturesque Lake Drummond. This link between Norfolk, Va., and Albemarle Sound in North Carolina still uses the locking systems of old. However, each opening drains 3 million gallons from Lake Drummond and it has become necessary in recent years to delay pleasure boats until several can be locked through simultaneously in the same direction.

Named by surveyor Col. William Byrd II, this cypress and juniper dotted peat bog was called a "glorious paradise" by a later surveyor named George Washington. Its features contrast sharply with the sand dune islands seaward of the waterway's dual exits onto Albemarle Sound. For the leisure traveler these dune islands exhibit rotted wooden hulks of shipwrecks with a history. Many were caused by helmsmen enticed into offshore shoals by thieves walking horses with bobbing lanterns hung round their necks—a despicable practice perpetuated in memory only by the village named *Nags Head* on the Outer Banks. The area is also famous as a waterfowl flyway stop and the wintering ground for flocks of Canadian Snow Geese.

In the French Cajun dialect used among the bayous of the Gulf Intracoastal Waterway the luxury of viewing these historical sites and national landmarks might be termed a *lagniappe* or bonus for waterway travelers.

For the Nation, the waterway represents a project producing many benefits paid for by a relatively small national investment in annual maintenance costs. Although minor jobs are sometimes handled by Corps-manned work boats, snag barges or survey boats, the major channel repairs and dredgings are mostly performed by private firms under contract to the Corps.

History has given the older parts of the Intracoastal Waterway an aura of tradition and permanence. Sporadic disruptions of the status quo indicate change is also a part of the waterway.

Those residing along its varied reaches either shudder at the portents of disturbance to nature's gifts or clamor for fulfillment of expansionist visions. Meanwhile, nature passively observes man's value conflict between progress and tradition—and subtly presents the compromising effects of time on man's physical changes.■

Events, Deeds & Deliberations

Hot Lake In a Cold Sea

Scientists in Sweden intend to research the biological effects of nuclear cooling systems on Baltic Sea marine life by creating a 220-acre lake *inside* the sea.

Several large islands in the Baltic will be linked by rock and earth-fill dikes to form the lake, which will eventually receive cooling system discharges transported underground from a nuclear energy site being built north of Stockholm.

Transplanted Coho Return

Beaver Creek, a small stream near Manchester, Wash., was the recipient of its first salmon run in history with the return of 1,655 coho during November and December 1972. The biologists counting the coho re-entering Beaver Creek estimated a substantial six percent return from the 81,000 coho released by the National Marine Fisheries Service.

Responsibility for the unusually high return belongs to the staff of the Aquacultural Experiment Station at Manchester, where young coho smolts incubated in other watersheds were transplanted into salt water pens near Beaver Creek. This experience conditioned them sufficiently to cause the young coho to return to Beaver Creek after maturing at sea.

The rewards of introducing salmon smolts to new streams such as Beaver Creek are the development of a new sport fishery off the mouth of the creek and the harvest of salmon eggs for sale to privately run hatcheries by the Washington Department of Fisheries.

Tar-Eating Bacteria

A cupful of bacteria dumped into a 31,000 gallon tank of ballast water aboard an Israeli supertanker multiplied a thousandfold within four days and ate up more than half the sludge, tar and oil in the water.

Cultivated from a strain found feeding on oil slicks along the Tel Aviv beach, the bacteria used in the experiment were grown by two American-born microbiologists for the supertanker experiment.

The ballast tank area inhabited by the bacteria was completely clean of oil stains in contrast to the normal deposits of sludge found after discharging oil contaminated ballast water into the sea in preparation for loading the next oil cargo. The remaining oil residue in the ballast water was reduced to tiny non-toxic droplets, becoming a source of food for marine life instead of prime source of oil slicks.

The two-man microbiologist team decided to perform this test at the original source of the ocean pollution when preliminary laboratory work showed the microbes being studied would not eat the carbon in the oil without having concentrated sources of nitrogen, phosphate and air available.

Chesapeake Bay's Coastline Sinking

A study of bench marks around Chesapeake Bay indicates the bay's coastal plain has sunk up to six inches since 1934 in some places and appears to be averaging a foot every 100 years.

Undertaken by the National Geodetic Survey at the Corps of Engineers' request, the study does not include the added effect of erosion or the rise in the bay's water level, which averages three inches a century.

Virginia's section of coastline is sinking fastest in comparison with the Maryland and Delaware sections. The heaviest subsidence in Virginia is the foot and a half per century measured near Smithfield.

Of future significance is the horizontal distance the shoreline will retreat along the nearly flat coastal plain and the eventual changes in tributary runoff patterns due to subsidence.

Deep Sea Dumping Retards Decay

The ocean bottom's unique environment apparently preserves refuse so well that still undecayed garbage may yet return to the surface to haunt us.

This aspect of ocean dumping came to light with recovery of a waterfilled lunchbox aboard a research submarine that accidentally sank in 1500 meters of water. Inside the lunchbox were perfectly preserved apples, bologna and bouillon broth.

Oceanographers involved in the discovery think large accumulations of foodstuffs containing starch, sugars, protein and fats can take up to 100 times as long to degrade under the high pressure-low temperature conditions at the ocean bottom than they would under the same temperature in shallow water. Thus, some scientists conjecture that garbage being dumped into the ocean today might float to the surface years later to litter our seas and beaches with undecayed organic debris.

Corps Uses Skylab Data

The Corps is making use of data from the first in the series of Skylab orbital space flights to investigate four areas of interest.

An Earth Resources Experimental Package (EREP) in the manned space workshop is surveying selected areas of the earth's surface in the visible, infrared and microwave spectral wavelengths. The purpose of these investigations is to test the application of this EREP data to the mapping of land uses and vegetation, delineating flood boundaries, studying near shore currents and sediment transport, and the monitoring of environmental changes that result from construction of a major reservoir.

The remote sensing techniques developed for Skylab—validated by the EREP investigations—is expected to become a major tool for use in the Corps' civil works program. Skylab provides the near real time data and wide area coverage that allows greater precision in evaluating large ecosystems and monitoring their changes.

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While he does this, others seek land-oriented recreation. *See page 14.*